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THESIS

TACTICAL EXERCISE REVIEW AND EVALUATION SYSTEM

by

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September 1999

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This thesis designed, developed, and implemented an integrated data collection and display system for supporting After Action Reviews (AARs) for tactical exercise participants. Data is collected with small, inexpensive, and easy to use computers. The exercise is immediately replayed during the AAR by depicting unit locations, actions, interactions, and dependencies dynamically over a digital map on a computer display. The system is intended to increase the learning of the tactical exercise participants and ultimately improve their performance in combat. Conventional range instrumentation systems (RIS) are expensive. Tactical Exercise Review and Evaluation System (TERES) can meet the principal RIS requirements for a fraction of the cost and provide the flexibility to function at any location. The data collection subsystem utilizes commercial Global Positioning System (GPS) receivers and handheld personal computers (HPC) to collect data. The HPC is programmed to passively record positions and time along with specific mission-essential tasks inputted by an observer. The display subsystem utilizes digital military maps to provide an event step animation of the collected exercise data. NATO standard military symbols are used to represent unit identities and locations. With TERES, leaders and subordinates can more easily learn valuable lessons about synchronizing maneuver with direct and indirect fire. Questions about mission accomplishment, individual performance, and command and control can now be discussed with an objective tactical picture.

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TACTICAL EXERCISE REVIEW AND EVALUATION SYSTEM

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ABSTRACT

This thesis designed, developed, and implemented an integrated data collection and display system for supporting After Action Reviews (AARs) for tactical exercise participants. Data is collected with small, inexpensive, and easy to use computers. The exercise is immediately replayed during the AAR by depicting unit locations, actions, interactions, and dependencies dynamically over a digital map on a computer display. The system is intended to increase the learning of the tactical exercise participants and ultimately improve their performance in combat. Conventional range instrumentation systems (RIS) are expensive. Tactical Exercise Review and Evaluation System (TERES) can meet the principal RIS requirements for a fraction of the cost and provide the flexibility to function at any location. The data collection subsystem utilizes commercial Global Positioning System (GPS) receivers and handheld personal computers (HPC) to collect data. The HPC is programmed to passively record positions and time along with specific mission-essential tasks inputted by an observer. The display subsystem utilizes digital military maps to provide an event step animation of the collected exercise data. NATO standard military symbols are used to represent unit identities and locations. With TERES, leaders and subordinates can more easily learn valuable lessons about synchronizing maneuver with direct and indirect fire. Questions about mission accomplishment, individual performance, and command and control can now be discussed with an objective tactical picture.

DISCLAIMER

The reader is cautioned that computer programs developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

The maps and overlays developed in this research are displayed in color on computer monitors. The screen shots included here are reproduced without color to facilitate the printing of this document.

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EXECUTIVE SUMMARY

This thesis designed, developed, and implemented an integrated data collection and display system for supporting After Action Reviews (AARs) for tactical exercise participants. During the exercise data is collected with small, inexpensive, and easy to use computers. The exercise is immediately replayed during the AAR by depicting unit locations, actions, interactions, and dependencies dynamically over a digital map on a computer display.

AARs should center on decision-making, synchronization of battlefield systems for maximum effect, and upon improving the overall process. Instead, participants often argue about what happened or disagree with each other about where they went and what they did. The discussions are hindered by a lack of objective observers. Tactical Exercise Review and Evaluation System (TERES) is intended to increase the learning of tactical exercise participants by providing immediate and objective feedback to exercise participants at the conclusion of training. The goal of this effort is to ultimately improve performance in combat.

Conventional Range Instrumentation Systems (RIS) are expensive. The United States Marine Corps validated a requirement for instrumented ranges that it could not afford to fund after beginning an acquisition program. TERES can meet the principal RIS requirements for less than $1,000 per individual and provide the flexibility to function at any location. The most important aspects of the RIS Operational Requirements Document (ORD) require support of force-on-force and live fire exercises

and support of Marines with feedback while still in the field. TERES is designed to meet these goals.

The data collection subsystem utilizes commercial Global Positioning System (GPS) receivers and handheld personal computers (HPC) to collect data. The HPC is programmed to passively record positions and time along with specific mission-essential tasks inputted by an observer. The GPS receiver provides time and position information. The mission-essential tasks are entered through a flexible system of graphic user interfaces (GUIs). The GUIs provide a quick and simple way of accurately recording training activities.

The display subsystem utilizes digital military maps to provide an event-step animation of the collected exercise data. This software operates on a standard laptop or desktop computer. GPS times provide the means to synchronize the data from the various HPCs. The synchronized data is on the examined computer display using a set of VCR-like controls that allows the viewer to scroll forward and backward easily. NATO standard military symbols are used to represent unit identities and locations. Colored graphics are used to indicate various direct and indirect fire weapons.

TERES has the potential to enhance development of tactical judgement and skills of all Marines conducting tactical training. Dynamic display of spatial information using common military maps and symbols permits immediate recognition of the interactions between units. TERES also reinforces the use of maps symbols and operations graphics as planning tools. The objective baseline established by this system enables frank and

professional discussion of unit and individual performance in a framework of the battlefield functions.

This low-cost, distributed data collection approach provides excellent resolution and meets exercise participant's needs for feedback at the conclusion of training. The technology for a simple distributed data collection and geographic display system using commercial-off-the-shelf computers and GPS receivers to provide immediate support and timely feedback for exercise participants is available. TERES demonstrates an architecture and implementation of such a system.

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I would like to thank all of the Marines who may benefit from the descendants of this idea for being my motivation.

I. INTRODUCTION

The more you sweat in peace the less you bleed in war.
Common military axiom

Quality training in the Marine Corps must be a way of life.
FMFM 0-1, Unit Training Management Guide

A. BACKGROUND

1. Marine Corps Training

The Marine Corps' major peacetime activity is training. Military leaders and historians both know there is a direct correlation between training and victory. Military training is conducted at all levels of organization and at all locations worldwide. Training takes place while in garrison, forward deployed, waiting for battle, or even between operations. The Marine Corps mandate for training is simple and compelling- the nation must have units ready for combat. [Ref.1:p 1-1] Training is a moral imperative not just a professional one. The human cost of war is tremendous and well recognized by the men who bear it. Military leaders recognize their responsibility for achieving success, not at any cost, but with the lowest human cost. Even success is expensive for the unprepared. Lack of preparation is remedied with training. From training comes the ability to follow procedures, to execute techniques, to apply tactics, and to integrate the capabilities of arms and services. Fulfilling the requirement to maintain combat ready individuals and units is the focus of the broadest effort in the Marine Corps.

Understanding unit training is essential to appreciating the requirement for a device like the one put forward in this thesis. A detailed explanation of the training process is essential to understand the scale and scope of the training effort and the areas needing improvement.

2. Unit Training

Training standards are the focus of the Marine Corps training system. The entire training system is based on, and all training programs are built around, standards. All training standards are derived from the specific mission requirements of the Marine Corps and developed using current doctrine. They insure that all Marines are being trained to perform activities oriented towards actual combat.

Unit proficiency and, ultimately, mission accomplishment relies first on training of the individual. Training of the individual begins at the entry level and continues through Military Occupational Specialty (MOS) schools. Individual training continues through each member's career. The Individual Training Standards System (ITSS) lists the Individual Training Standards (ITS) for each officer and enlisted rank by MOS. The ITSS also includes the tasks, conditions, and standards for each ITS. Unit collective training begins after a period of ITS training and refreshment has concluded.

Collective training standards are published with the Marine Corps Combat Readiness Evaluation System (MCCRES) as Mission Performance Standards (MPS), published in Marine Corps Order (MCO) 3501 series. MPS prescribe the specific tasks that a unit must perform to successfully execute a particular mission. MPS can be thought of as mission essential tasks that constitute unit training requirements. MPS also

serve as a means to evaluate the current training of a unit. They help the commander determine the relative efficiency and effectiveness of his unit and provide an outline for corrective action when mission weaknesses are noted.

Commanders allocate resources for training based on anticipated combat requirements. Training resources can become very scarce. Lack of training funds, lack of training areas, and lack of personnel are impediments to training. Focusing on the combat requirements recognizes that proficiency cannot be achieved on every training task. Commanders achieve successful training programs by narrowing focus to a reduced number of tasks. These tasks make up mission-essential task lists (METL). The mission essential tasks are extracted from a larger number of possible training tasks. The unit METL may outstrip training resources but it narrows focus and provides structured planning efforts. An example of a portion of a Marine Expeditionary Unit (MEU) METL and a supporting Battalion Landing Team (BLT) METL is shown in Table 1.

The commander has the responsibility for developing a training strategy for maintaining unit proficiency in METL tasks. The commander's guidance results in a Training Plan designed to focus organizational activities on achieving METL proficiency. The Training Plan provides long term and short-term focus for the unit. The long-term focus comes in the form of a cycle through which the unit will move in order to train for each METL task. The short-term focus takes the form of a training calendar. The training calendar contains many different individual and unit training events. The training calendar is also where requirements of the METL meet the reality of the

resources. There are simply never enough resources to fulfill every unit's requirements. Commanders are compelled to decide on which critical METL tasks to train.

	MEU-METL
MPS 7A.6	NONCOMBATANT EVACUATION OPERATION
	BLT-METL
TASK 7A.6.1	CONDUCT INITIAL PLANNING (NEO)
TASK 7A.6.3	PERFORM INTELLIGENCE FUNCTIONS
TASK 7A.6.4	CONDUCT ADVANCE PLANNING
TASK 7A.6.5	PERFORM TASK ORG. OF NEO FORCE
TASK 7A.6.7	PLAN COMMUNICATIONS
TASK 7A.6.8	CONDUCT TACTICAL DECEPTION PLANNING
TASK 7A.6.13	PREPARE FOR NEO MISSION
TASK 7A.6.16	PREPARE TACTICAL DECEPTION PLAN
TASK 7A.6.17	CONDUCT HELOCOPTERBORNE MOVEMENT
TASK 7A.6.18	EXECUTE TACTICAL DECEPTION
TASK 7A.6.20	WITHDRAW THE NEO FORCE

Table 1. Marine Expeditionary Unit Mission-Essential Task List. [FMFM 0-1 p.5-2]

A tremendous amount of effort is expended in training Marines and sailors for combat. The training system provides the focus for all individual and team training as a predicate for unit training events. As we progress through the training system the nature of the training changes from numerous drills and instruction aimed at individuals and teams to singular unit exercises involving up to 1000 or more people. Unit training is where Marine Corps organizations learn their lessons for combat. Unit training ensures our effectiveness as a fighting force. There is tremendous focus by commanders on the

training system as a method to ensure that individual and team training progresses satisfactorily before precious unit training is conducted.

The capstone of unit training takes the form of Field Training Exercises (FTX) and Live Fire Exercises (LFX). FTXs are high-cost, high-overhead exercises conducted under simulated combat conditions in the field. [Ref.1:p.11-36] They exercise command and control of all echelons against an actual or simulated Opposing Force (OPFOR). FTXs use all unit personnel and equipment. FTXs are the only exercises that fully integrate the total force in a realistic combat environment. Emphasis is normally placed on maneuver of units. FTXs can involve rehearsing employment of weapons while maneuvering. Participants gain an appreciation of how the factors of time and distance influence planning and execution of military operations. [Ref.1]

Live Fire Exercises are high-cost, resource intensive exercises in which player units maneuver and employ organic and supporting weapons systems using full-service ammunition with integration of all combat arms, Combat Support (CS), Combat Service Support (CSS), and aviation functions. [Ref.1:p.1-41] LFXs are executed under simulated battlefield conditions and are employed by commanders to train integration of fire and maneuver against a realistic target array.

FTXs and LFXs have much in common. Both are designed so each Marine gets experience employing his weapon or performing his job in a close approximation of combat. FTXs and LFXs also provide the leaders tactical experience and provide them opportunities to hone their judgement in employing their unit as a whole. Finally, both

LFXs and FTXs compete for the scarce resources of personnel, ammunition, ranges, maneuver area, money, and especially time.

After the expenditure of great effort to plan and perform training, the commander must strive to get the maximum benefit from the training. The lessons learned in unit training are generally aimed at commanders, staffs, and small unit leaders. These people are not fully trained during the individual training phase. They can only learn many of their skills in unit exercises. The success of any unit-training event does not rest solely on prerequisite training or the actual conduct of the FTX. Lessons learned for combat success are as important as safe completion of the tactical problem. The after action review (AAR) is where most lessons are learned from unit training. The AAR is a form of critique or evaluation providing immediate feedback to exercise participants. Training evaluations should reveal valuable information emphasizing goals, standards, and commander's guidance for the exercise. Critiques should actively involve the people being evaluated and should answer three questions:

- What happened?
- Why did it happen?
- How can it be done better? [Ref.1:p.10.3]

Information from AARs can affect unit training programs and unit special operating procedures (SOPs). Information from Corps-wide evaluations can change doctrine, force structure, literature, and equipment.

AARs are not critiques in the normal sense. Instead they are professional discussions of training events. Leaders should guide AARs to ensure that important lessons are openly discussed. Participants who identify what went right and wrong learn

much more than when lessons are dictated. AARs encourage discovery learning. In this way, Marines and junior officers get involved in their own professional development and learn more in the process. [Ref.1:p. D-1]

AARs cover both strengths and weaknesses associated with:

- Tactics.
- Combined arms employment.
- Command and control.
- Communications.
- Survivability.
- Personnel and logistics support [Ref.1:p. D-2].

For a large FTX, each echelon's AAR discusses items and events relating to the exercise objectives. For example, topics for a Company level AARs would include:

- Engagements.
- Use of terrain.
- Suppression of enemy weapons.
- Coordination of fire and maneuver.
- Employment of antitank weapons.
- Employment of other organic and supporting weapon systems. [Ref.1:p.D-4]

The previously described LFXs and FTXs are both conducted with two possible modes of supervision. The most common is unit-supervised training. The leader conducting the training is responsible for leading the AAR and guiding the discussion to the important topics in addition to being a participant. Unit supervised training takes place daily in local training areas at every location where there are Marines stationed. The second mode of supervision takes place when dedicated observers are accompanying the exercise participants. This mode is far more resource intensive because of the requirement for experienced people to act as observers. Observers are commonly

referred to as controllers or evaluators. The Marine Corps has two ways of facilitating this type of exercise supervision. The preferred is the dedicated unit of controllers stationed at Marine Corps Air Ground Combat Center, Twenty-nine Palms, CA (MCAGCC). These Marines have the assigned task of providing feedback to the exercising units that conduct the ten Combined Arms Exercises (CAX) under their supervision each year. At all other Marine Corps bases a less formal controller support effort takes the form of a Tactical Exercise Control Group (TECG) formed from officers and Staff-Non Commissioned Officers from similar units not participating in the evaluated exercise. These personnel-intensive exercises usually occur at home station and are reserved for units preparing for deployment or large scale exercises of high level interest.

In either of its forms, the controllers' organization is responsible for adding realism in the form of intelligence, recording events, and providing feedback during the AAR. The controllers rely on hastily scribbled notes to stimulate their memories.

3. Need

> Without question, the most important part of any exercise is the critique, yet it is the first to be sacrificed or reduced due to lack of time or competing priorities. Critique sessions should be a positive means of providing meaningful feedback aimed at helping our units to improve.
>
> 32nd Commandant's Guidance, ALMAR 023/99

A tremendous effort has gone into organizing a training system that ensures units spend their time on the highest-value training and that prerequisite training has been completed before progressing to higher tasks. Little has been accomplished in the area of

improving or supporting the AAR at the end of FTXs or LFXs to heighten the learning experience of participants.

Whether externally or internally evaluated, it becomes the responsibility of the chief controller or the unsupported exercise leader to establish an agenda and lead the AAR. The AAR leader depends upon a complete picture of what happened during the exercise. [Ref.1:p. D-2]

A complete picture is rarely achieved. Events occur at high speed, with high frequency, and over great distances. Even in a relatively small company-level FEX no single person can observe all the events especially if they are preoccupied with the accomplishment of the overall unit mission.

The AAR depends on the experiences of every participant to form a picture of the action. This must be accomplished in an atmosphere of effective learning. Leading an effective AAR is difficult for even the most seasoned observer. The agenda for the AAR is hastily assembled after the conclusion of the exercise. If an exercise is supported by observers, then the participants may benefit from notes taken by the observers during the tactical play. Terrain models are often used to stimulate memories while markers are used to represent the movement of units, vehicles, and individuals.

The issues of distance and time as they pertain to military operations are primarily spatial. Verbal discussion, based on hastily scribbled notes or distracted memories of the harried unit leader, do not adequately portray the complex actions and interactions that take place during military operations. Consequently, the doctrinal format for an operations order (OPORD) requires preparation of map overlays called operations

graphics that must contain unit locations, anticipated movements, and operational boundaries, in addition to checkpoints and phase lines, to coordinate the movements in time. Units' locations and enemy locations are tracked on maps containing graphic control measures from the OPORD. Locations are updated as units report movement. The maps with these elements comprise the basic sources of information for tactical decisions during operations.

The FTX and LFX create the opportunity for the leaders at all levels to gain valuable experience in understanding distance and time relationships as they pertain to their unit and mission. The issue of distance and time is the first hurdle to understanding the interactions of each participant's performance with respect to tactics, techniques and procedures. A goal for the tactical leader may be an understanding of the time it takes for reconnaissance to be conducted, orders to be issued, units to prepare and position themselves, coordinated movements to be executed, and fires to be coordinated, all against an uncooperative enemy on varied terrain. Other leaders gain experience in conducting timely repair and support of equipment in actual use over large areas, repairing equipment casualties for the next battle of the day. The lessons are as varied as the levels of leadership. The Regimental Commander studies how much ground he can expect his Marines to cover in 24 hours. The Platoon Commander explores why his platoon took 24 minutes to consolidate on the objective.

A Range Instrumentation System (RIS) can provide high-resolution reconstruction of unit training performance. The ability to replay the exercising unit's actions can serve to focus the AAR. RIS can provide an objective viewpoint from which

to discuss the training. Exercise participants do not need to be distracted by debates about location and timing of actions during the AAR. Instead, participants should examine why actions were taken and what alternatives were available. [Ref.1:p. D-1] Focus can be placed on developing military judgement in leaders and evaluating performance of all participants as a unit. This RIS serves to display actions to quickly develop a reconstruction of the training and get to the heart of the issues to be examined. A RIS can prevent participants from missing potential learning points or disguising poor performance. Truly, a picture is worth a thousand words.

A large portion of any AAR discussion on a tactical exercise is related to topics that are spatially oriented, time oriented, or both. This is demonstrated by the frequent use of terrain models and maps in AARs. A RIS provides spatial and time referenced data in a graphic display. "Graphic display achieves its highest goals when it allows access to important, complex information; when in John Tukey's words, `it forces us to see what we never expected.'"[Ref.2:p.3] Range Instrumentation should not automate the AAR process but augment the unit leader. Range Instrumentation can help us overcome the human weaknesses associated with memory and perception. Almost every tactical unit conducting any sort of training could benefit from RIS support to heighten training experience.

4. Current and Proposed Systems

The U.S. Army has three major instrumented ground combat training centers. The foremost is the National Training Center (NTC), Ft. Irwin, CA. NTC has a primary mission of providing realistic instrumented training to mechanized U.S. Army units that

travel to the center for training. The base consists of approximately 430,000 acres instrumented for exercises. The instrumentation system utilizes transponders on military vehicles backed by an antenna network for a microwave communications system that collects telemetry and activity data. The telemetry and data collection system is fixed to the training site. Over 800 contractor personnel provide the expertise for the NTC RIS. NTC is designed to handle a battalion-sized task force with two or three maneuver companies. Data are collected on vehicle locations and direct and indirect fire weapons. Data are collected at the operations center for playback. Exercises smaller than battalion-sized are not supported. The Combat Maneuver Training Center (CMTC), Germany is a mechanized unit training facility. It is similar to NTC in equipment and focus but smaller in scale. The Joint Readiness Training Center (JRTC), Ft. Polk, LA is similar to NTC but with an emphasis on light infantry. [Ref.3:p.22]

The U.S. Marine Corps has no ground RIS. In 1995 a Program Objective Memorandum (POM) was developed for POM year 1998 to fulfill the deficiencies called out in Center for Naval Analysis CRM 93-117, *Training Mission Analysis*. The system considered would be designed to support training at all four continental U.S. training bases. System procurement alone would have cost $186,276,000 in 1995 dollars. [Ref.3:p 2] The system initiative was not funded in 1995 and no RIS development for ground combat is underway inside the Marine Corps.

5. Tactical Exercise Review and Evaluation System(TERES)

The Tactical Exercise Review and Evaluation System (TERES) developed in this research is a support system for AARs. At the conclusion of an exercise the participants

assemble at a common location and view a military map rendered on a computer display with appropriate operational graphic control measures. The map can be scaled and scrolled as required to display the geographic area desired. Unit and individual movements and selected actions are replayed as overlays on a map to aid in the AAR. VCR-like controls permit rewinding for review and pausing for discussion. This system is adaptable to any training location and various sized units.

The data to animate the AAR is accumulated on a 3" by 8", 30 oz. Handheld Personal Computer (HPC) with a Global Positioning Receiver (GPS) shown if Figure 1. Any unit can have its performance in many METL tasks recorded by an accompanying observer carrying the device. If an observer is not available or not desired, the data collection device can be operated in a "tracking only" mode. In this mode it is possible to wear the HPC and collect only position information. The estimated cost to equip one element, team, or squad, for data collection is less than $1000. The display subsystem functions on any Personal Computer, Macintosh, Linux, or Unix machine.

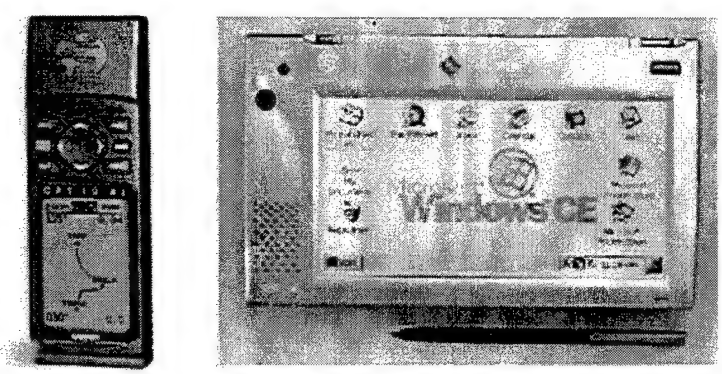

Figure 1. Global Positioning Receiver and Handheld Personal Computer.

B. STATEMENT OF THESIS

It is possible to enhance participants' military judgement and tactical learning experience by introduction of Range Instrumentation. This thesis demonstrates a low-cost, handheld RIS that gathers and then displays basic spatial and temporal data dynamically in a format familiar to military personnel. TERES is intended to assist observers and participants understand what happened simply and objectively. Participants will then be able to focus on why events happened and how they can be done better. The system is designed in a minimal fashion to a set of specific training tasks but is capable of expansion as desired. The design also allows other users to develop their own applications for other data collection and analysis tasks.

The remainder of this thesis is organized as follows. Chapter II presents the RIS requirements and the technology that fulfills them. Chapter III will describe modeling a tactical exercise with maps, overlays, and graphics. Chapter IV displays the system architecture and design. Chapter V demonstrates system operation with a sample scenario. Chapter VI examines possible future developments. Finally, Chapter VII offers conclusions about this research.

II. REQUIREMENTS AND TECHNOLOGY

The need to achieve success on the battlefield at the lowest possible human cost is the incentive for the requirement to improve military preparedness through unit readiness and ultimately creates the inescapable drive to improve training. This drive for better training and more of it has practical limitations of money and time. The essentials of the Range Instrumentation System (RIS) requirement can be filled by low cost technologies that have exploded in the consumer marketplace in recent years. Without these technologies the system developed in this research would not be possible. Expected developments in these same arenas will enable us to extend our expectations for RIS in the future.

A. REQUIREMENTS

> Incorporate simulation, instrumentation, and automation into training range upgrades.
>
> The Marine Corps Master Plan for the 21st Century

The Marine Corps Combat Development Command (MCCDC) published an Operational Requirements Document (ORD) for RIS, contained in Appendix C, in response to a validated Mission Need Statement (MNS). The requirement for RIS relates to the Mission Area of Command and Control (C2)[Ref.5]. This RIS ORD was published during initiation of the acquisition program to develop and field four systems. The system envisioned included instrumentation of every weapon system, individual, and vehicle with all sensors providing real time data to a central data collection point. This

philosophy is reflected in the requirements contained in the ORD, the cost of the contemplated system, and the failure of the program.

The ORD contains eight requirements for collection and use of data. Only two of the requirements focus on the issue of supporting training and providing objective feedback to Marines. One requirement indicates a precision of less than one meter is required. Five of the eight remaining requirements center around the subject of near-real-time two-way communication between a central data processing unit handling adjudication of engagements, simulation of other forces, and real time data collection. [Ref.5]

This thesis focuses on the two core requirements of supporting Marines training. The first requirement is the need to support live fire or force-on-force training. The second requirement is to provide support in the field. The requirements for near-real-time data display, interactions with simulations, and extremely high-resolution data compete with the two core requirements by making the contemplated system economically infeasible.

B. TECHNOLOGIES

A technologically feasible alternative exists to fulfill the ORD requirements focusing on improving combat skills. This option consists of low cost, commercially available, already understood, easily modified elements that combine to meet the RIS needs.

1. Handheld Personal Computers

Handheld Personal Computers (HPC) have exploded in the consumer electronics marketplace. They are seeing an expanding base of consumers in our technologically literate society. HPCs have proven themselves useful with features including calendars and address books. They continue to expand in their capabilities in response to market forces. New features including internet browsers, e-mail programs, word processors, spreadsheets, graphics packages, and handwriting recognition packages have become common.

The physical forms in which these devices are available is varied. HPCs can come with keyboards or just touch screens. Some are available in sizes small enough to fit unobtrusively in your shirt pocket.

These devices can be programmed to do specific desired tasks. There is a pallet of computer software languages aimed at supporting these small devices. The two most common HPC operating systems in the market place are WindowsCE from Microsoft and PalmOS from 3Com. Both of these systems support the C++ language [Ref. 6]. The WindowsCE operating system also supports two Microsoft languages, Visual Basic [Ref. 7] and J++ [Ref. 8], a version of Java [Ref. 9].

The HPC is designed to compete with the traditional desktop computer in the domain of the most common user functions. The designers of these devices focused on providing some limited functionality for the consumer who does not want or need the full features of a word processor, spreadsheet, or internet browser.

The software for the HPC has a common theme- desktop computer look with a subset of the features. The word processor programs, spreadsheets, and internet browsers look like their desktop counterparts. The issues surrounding the features available are arguable but one feature is clear, if you can use a desktop computer you can operate a HPC. The mixture of icon and menu based interfaces, referred to as a Graphical User Interface (GUI), are undeniably the same.

The HPC hardware is capable. Necessarily so, because the GUI style software interface requires a lot of processing power. The devices available today consist of a 80-100 Mhz processor with memory ranging from 4 to 32 Megabytes. Despite their small size HPCs are powerful computer devices. HPCs are more powerful than many early desktop systems. They integrate with a wide variety of peripherals. HPCs can host a spectrum of modems, LAN cards, external monitors, facsimile devices, printers, and even hard drives.

The HPC is a small, inexpensive, and easy to use device that can be customized to perform powerful tasks. Their portability, economy, and programmability serve to bring solutions to a whole new type of consumer. The individual on the battlefield is already trained in using the interface on these devices. We just have to teach the HPCs what to do!

2. Global Positioning System

The Global Positioning System (GPS) is already familiar to almost every battlefield participant. GPS consists of a network of satellites broadcasting time signals towards the earth. When outside, a GPS receiver can tie together signals from several

satellites and calculate its own position. Once a receiver has locked in on one signal, it has a time signal. The receiver can calculate latitude or longitude after it locks onto a second satellite. With a third satellite, the receiver can calculate both latitude and longitude. A fourth satellite permits calculation of altitude. The greater the number of satellites, the greater the accuracy. More than four satellite signals permit the receiver to make uncertainty calculations. [Ref 10]

Due to defense concerns, only degraded GPS signals are available to the public. The degraded signal imposes errors in location calculations on the order of 100 meters. Military GPS receivers are not affected by the degradation but they are expensive and tightly controlled. Terrestrial differential beacons provide correction for these degraded signals. Differential beacons are provided at some US coastal regions to improve accuracy of GPS positions. Differential beacons are provided at coastal areas with high volume or constricted maritime traffic for increased safety. [Ref 10]

There has been an explosion in the number of GPS users. Travelers, boaters, pilots, hikers, and sportsmen of many types have discovered the utility of this simple system. The number of consumers both in and out of the military has driven GPS receiver prices down and performance up.

The proliferation of GPS receivers in the public marketplace has been accompanied by a flurry of related consumer devices and software to take advantage of this data source. These consumer devices center on the boating industry. An exchange of data often takes place between GPS receivers and marine radar units, fish finders, auto-pilots, and navigation plotting aids. To support these devices the National Marine

Electronics Association (NMEA) published a standard. NMEA 0183 version 2.0 is the current implementation. [Ref. 10] This makes it easier for multiple manufacturers to produce equipment that uses GPS information.

The GPS NMEA 0182 standard output is composed of "sentences," shown in Figure 2. Each sentence begins with a string that indicates what kind of sentence follows. The sentences contain a variety of information in formats determined useful to a wide range of applications. The sentence that contains the information we need begins with the string "$GPGGA" and is known as the "fix" sentence. The elements of the $GPGGA sentence are shown in Appendix A.

```
$PGRMZ,498,f,3*1E
$PGRMM,WGS 84*06
$GPBOD,,T,,M,,*47
$GPRTE,1,1,c,0*07
$GPRMC,180312,A,3400.000,N,06854.375,E,000.0,360.0,050699,002.4,E*76
$GPRMB,A,,,,,,,,,,,V*71
$GPGGA,180312,3400.000,N,06854.375,E,1,08,2.0,151.6,M,-37.5,M,,*67
$GPGSA,A,3,01,,14,15,16,18,19,22,25,,,,3.1,2.0,3.0*30
$GPGSV,3,1,09,01,34,083,43,04,03,322,00,14,77,266,49,15,10,203,34*75
$GPGSV,3,2,09,16,48,310,46,18,17,298,38,19,11,244,34,22,54,096,46*7C
$GPGSV,3,3,09,25,24,050,40,,,,,,,,,,,*40
$PGRME,15.0,M,22.5,M,15.0,M*1B
```

Figure 2. Global Positioning System data output.

3. Java

Java is a computer language developed in 1995 by Sun Microsytems, Inc. Compilers and other support tools are provided at no cost. Many efficient compilers and Integrated Development Environments (IDEs) are sold by third parties.

Java programs are compiled to an instruction set that is interpreted by a Java Virtual Machine (JVM). Compiled Java programs can be executed on any computer hardware running an operating system that has a JVM written for it. Current implementations of the JVM include Windows 95/98/NT, Solaris, UNIX, Linux, and Macintosh. Microsoft released a J++ Virtual Machine (MSVM) for Windows CE HPCs. Any compiled Java program can be executed on any of these computer systems without rewriting or recompiling. This capability, called "platform independence," alone serves to make Java the strategic choice for developers. New JVMs are being developed for Palm Pilot and Windows CE HPCs. Java programs will run without modification on these new small HPCs.

Java is a full featured language that supports Object Oriented Programming (OOP). OOP focuses on program data and the interfaces to it. It has replaced procedural based programming. Objects have certain properties and certain tasks they can perform. By putting data structures first and then writing an algorithm to manipulate the data you reduce a program from a large monolith with a large internal data structure to a small data object and a group of small objects to perform the various functions you desire.

The interface between the computer and the user is the GUI. There are many ways to render this interface. GUIs all utilize similar systems of buttons, windows, menus, radio buttons, and text areas. The most widely used is the familiar desktop GUI on personal computers. This interface is being echoed on the smaller HPCs. Users are already trained in using GUIs due to the large number of computers sold with a desktop operating system (for example, Windows or Macitnosh OS). The desktop style of GUI is

a defacto standard. Many military members have already been trained to use these GUIs in their homes, schools, universities, and on the job.

Java supports these kinds of GUIs. Since Java runs on a variety of smaller devices these GUIs work on them. The Java GUIs used on the devices are based on the Abstract Windows Toolkit (AWT) and Java Swing. Both of these Application Programmer Interfaces (API) accomplish the same tasks in different technical manners and provide different features. Both result in the familiar desktop style interface that allows the unsophisticated operator accomplish sophisticated tasks with ease. The system developed in this research uses both AWT and Java Swing to accomplish various tasks.

4: Reusable Software Components

Software designed with the idea of reusability sped the development of TERES. Software reuse permitted challenging design obstacles to be overcome. In fact, without software reuse this system might not have been successfully developed. Software designed by other developers solved the problems associated with reading the GPS output, organizing the collected data, and displaying the data on military maps with their associated geodesic intricacies. Several of these components were used unchanged in ways unimagined by their developers.

The design of TERES also supports the reuse of software. TERES stimulates expectations expanding beyond training to the battlefield. These battlefield capabilities may be incorporated into the existing architecture or future systems may absorb the current system.

Software reuse also protects system investment against the rapid changes taking place within the hardware market. Reusable software will run on the hardware of tomorrow. Reusable software will also be adaptable to new hardware not yet envisioned.

III. THE TERES MODEL

The TERES system uses digital military maps and military symbols and combines them with recorded data on unit movements and actions to form an abstract model of unit activities. Animation of the collected data over a backdrop of the military map with appropriate unit symbols and a graphic portrayal of the leader's plan allows the training participants to quickly analyze their own performance and their role in the overall success or failure of the exercise mission.

By utilizing common military planning tools as our analysis context, TERES is easily understood by the target audience. Subordinates' military judgement and experience with the military maps and operations graphics will grow by using planing tools during the AAR. TERES turns planning, execution, and the AAR into a full cycle, improving learning and the next plan.

A discussion of each of the components of the TERES model follows.

A. MILITARY MAPS

Military maps lie at the center of the military planning effort. The military map provides information otherwise unavailable to the planner because the terrain it represents may be unfamiliar and inaccessible due to time, distance, or the enemy. Military members learn to interpret the features of the terrain represented on the map through training and practice. The contour lines drawn on the military map are an abstract representation of the hills and valleys of the area. The interval and spacing of the contour lines are interpreted for slope and visibility between locations. After years of

planning on maps and then moving over that same terrain, most leaders have developed this judgement to a high form.

Military maps also contain representations of the many geographic features of an area. Buildings, roads, bodies of water, and almost any other recognizable feature can be represented on a military map.

Terrain relief and other geographic features are insufficient to permit efficient communications of military information. To remedy this shortfall, complex mathematical models have been devised to accurately report locations. The two most commonly used are Universal Transverse Mercator (UTM) and Geographic Reference System (GEO). Within the UTM system, military units use what is known as the Military Grid Reference System (MGRS). This system is found on most tactical level military maps. The MGRS divides the world into 1 km. square grids. Each grid has a unique designation and can be further subdivided to describe positions within each grid. The GEO reference system consists of the common latitude and longitude systems, in familiar degrees, minutes, and seconds notation. All military maps also have reference information for using this coordinate system. The GEO reference system is predominately used for ship and plane navigation, and survey work. The GEO system is not frequently used by units conducting ground tactical operations, but it is well understood. Both of these representations of locations on the map and the earth are used in the system developed in this research.

B. MILITARY SYMBOLS

In order to train or fight, commanders must issue instructions to subordinates. A common language of operational terms and military symbols is necessary so instructions can be communicated rapidly and with minimum risk of misunderstanding. Symbols and definitions are standardized jointly between the Marine Corps and Army and also with North Atlantic Treaty Organization (NATO) Armed Forces. [Ref 11] The TERES representation of the completed training unambiguously portrays unit movement to the participants.

C. OPERATIONS GRAPHICS

Military symbols are also at the heart of the operations graphic. The operations graphic provides the commander a technique to express an operational plan, concept, or situation to subordinates. Traditional operations graphics take the form of clear plastic overlays used in conjunction with a paper map. Commanders and staffs produce multiple overlays, each with a different purpose. An overlay may contain friendly positions, enemy positions, route classifications, chemical contamination, indirect fire targets, or may combine any of these with a host of other topics. The combination of unit positions, boundaries, routes-of-march, target locations, and other control measures with a map are an indispensable tool for portraying battlefield activity. The operations graphic is used by commanders to plan, communicate, and track an operation. TERES combines the same graphic overlays with unit actions during the review of the training. The operations graphic helps the leader of the AAR keep the participants focused on the critical tasks to be learned from the training.

D. LOCATIONS, ACTIONS, AND INTERACTIONS

Unit locations are indicated by the use of the appropriate symbol and are connected to the unit location by a small colored line. Units interact in these exercises by firing weapons at each other. These weapons include direct fire weapons like rifles, machine guns, and missiles. Indirectly fired weapons such as artillery and mortars are also used. The model of the exercise displays these actions graphically. The direct fire weapons appear as colored lines. The lines are drawn between the locations of each unit. Associations between weapons and colors are contained in Table 2. Indirectly fired weapons appear as white stars. The white stars appear at the location the attack was requested with a notation indicating requesting unit. If the actual impact of the artillery rounds can be judged during a live fire exercise then these impacts are displayed as yellow stars. A TERES playback is pictured in Figure 3.

Unit symbols may be relocated to reduce clutter on the map by grasping the upper right corner of the symbol with a mouse and dragging it to another location. The symbol staff changes size to keep the symbol and the location connected.

Weapon	Color
M240 7.62 mm Machine Gun	Yellow
M2HB .50 cal. Machine Gun	White
Dragon Anti-Tank weapon	Orange
TOW Anti-Tank weapon	Red

Table 2. Direct fire weapon colors.

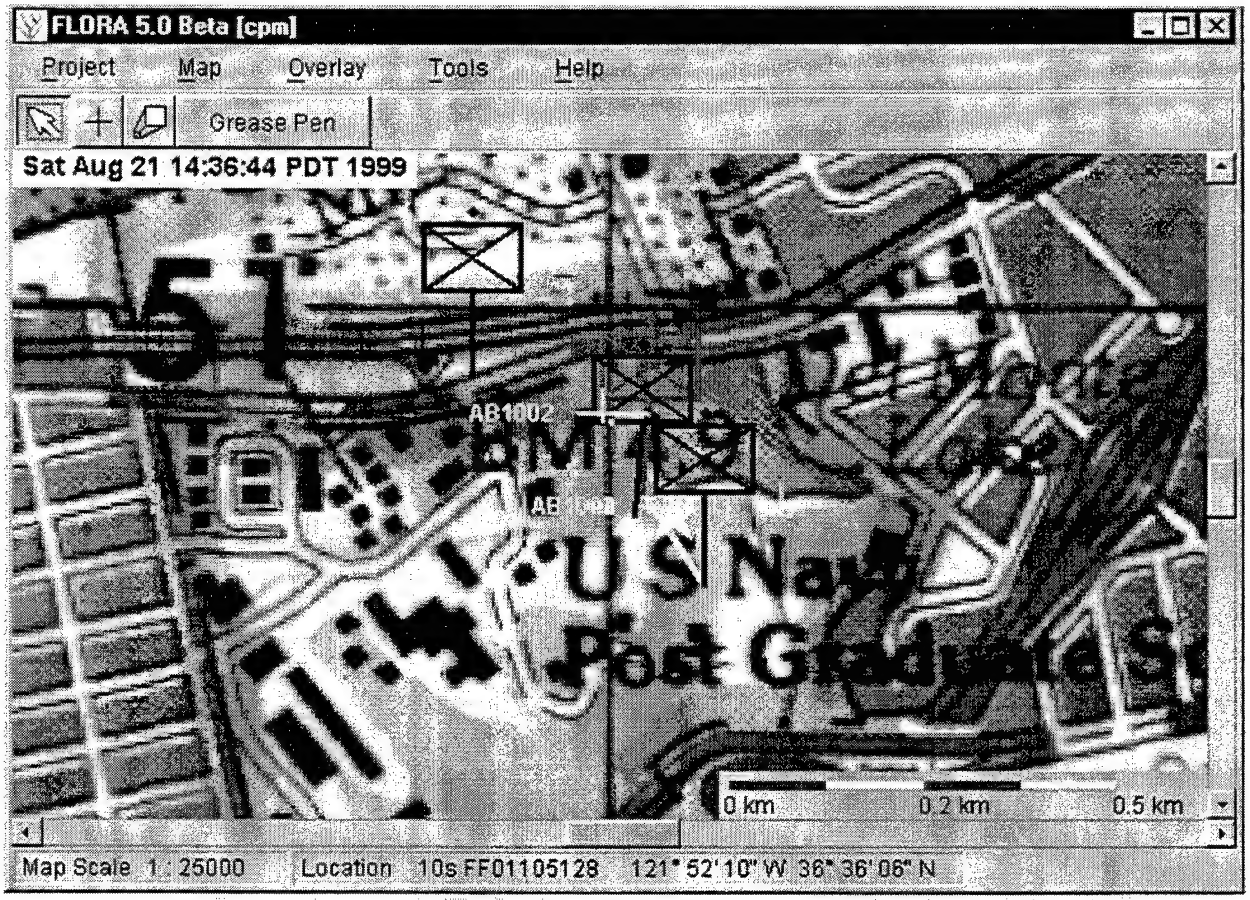

Figure 3. Flora map display with TERES playback.

IV. DESIGN ARCHITECTURE AND COMPONENTS

TERES consists of two major subsystems. The data collection subsystem combines GPS satellites, GPS receivers, and HPCs to collect time, position, and performance data. The display subsystem is resident on a desktop or laptop computer and collects data from the HPCs via a network connection, disk, or cable at the end of the exercise. An event step animation of the exercise data is displayed over digital military maps. The general system architecture appears in Figure 4.

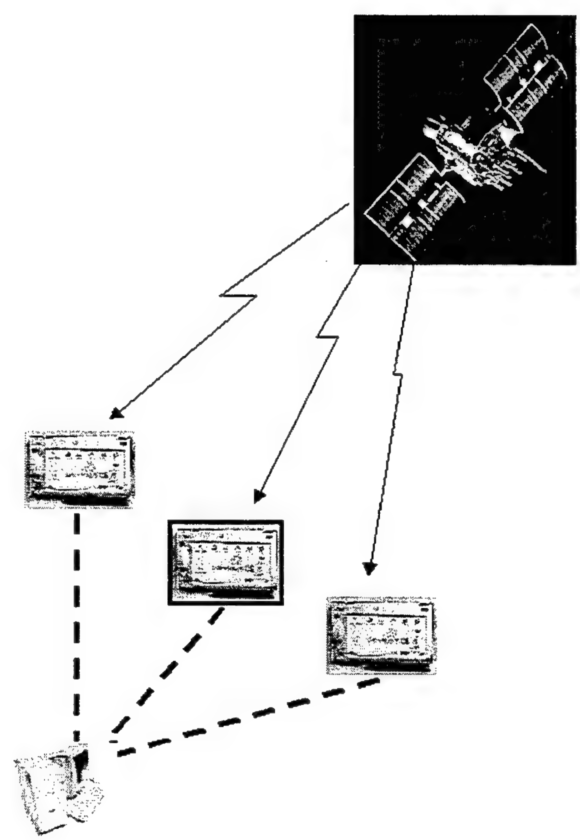

Figure 4. General system architecture.

A. DATA COLLECTION SUBSYSTEM

The data collection subsystem has hardware and software components. The hardware consists of a HPC or laptop computer and a GPS receiver. The GPS must provide data in the NMEA standard. The software provides the functions to handle the GPS data. The general architecture is reflected in Figure 5.

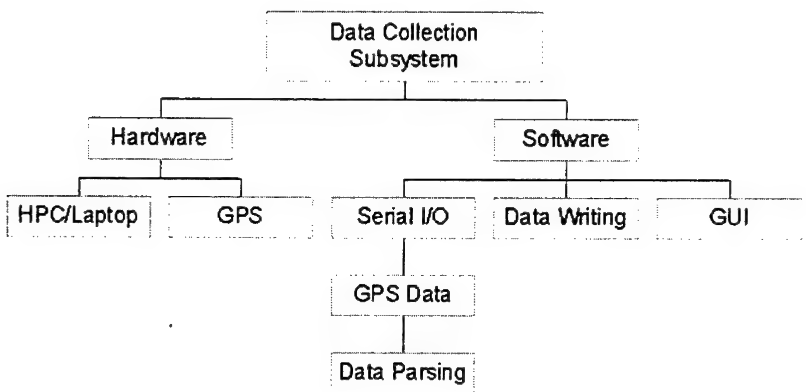

Figure 5. Data Collection architecture.

1. Software Design

The software has three major elements, the serial communications element, the GPS display element, and the user interface element.

The data collection element can be better understood by examining the three logical program threads that execute simultaneously.

One thread makes use of the serial communications element containing Sun Microsystems' COMM API to provide a link from the serial port to the GPS display element. The communications element performs asynchronous reading of the port when bytes from the GPS are available. The asynchronous design allows bytes to be passed

from the port to the GPS processing element without problems caused by blocking when the buffer is full.

The GPS data from the serial communications element is passed to the GPS parsing routine. The GPS parsing routine checks the bytes to see if they are understandable information. If the bytes are readable and consist of the correct NMEA GPS sentence, the GPS parsing routine will attempt to separate the sentence into the component parts that contain the various elements of GPS information. When a NMEA GPS sentence is successfully parsed, the routine instantiates an object of the NMEAPositionStatus class, shown in Appendix C, to replace the previous one created earlier. This cycle continues with the NMEAPositionStatus object being updated every 3-5 seconds.

A second logical thread simply writes unit log file position entries, shown in Appendix E. The log files written by this portion of the code begin with the entry "Posrep." These entries are posted every 13-15 seconds automatically, and provide passive position reporting for the unit.

The third logical thread creates the user interface, the cascading menu system, and writes the observed activity entries in the log file as entered by an observer. This interface also includes a display of the current GPS object in the system and the last log file entry made by an observer or by the passive position recording feature.

All three of these sections of the GPS processor element function in harmony using Java threading features. InputStreams and OutputStreams are passed between logical threads without conflict using "Pipes." Pipes provide protected conduits for

information. Sections of code are also synchronized if they are shared by more than one thread. Synchronized blocks prevent two threads from trying to execute the same line of code at the same time. Synchronization requires one thread to yield to another in situations that threaten to block continued execution of the code, avoiding an irrecoverable error.

2. GPS Output Filtering and Parsing Classes

The fundamental logic for processing the data received from the GPS receiver is presented in code from "Java Networking and Communication." [Ref.10] These Java examples were used without modification and form the nucleus of the JavaGPS classes. These examples made development of the JavaGPS possible without any specific detailed knowledge of GPS output or filtering algorithms.

The JavaGPS classes include all the software necessary to read GPS data from the serial port or PCMCIA port on a WIN 32-based computer system. These classes handle the reading of the data streaming from the GPS and process it into a Java object containing instance variables representing the position and time information sent from the GPS.

B. DISPLAY SUBSYSTEM

After the end of data collection the files must be compiled in one location, preferably on the computer being used for playback. This subsystem consists of one element that processes the exercise data for display over a map and records this data for viewing later and a second element that reads the recorded data and displays them for examination and review.

1. Components

The display subsystem contains components developed in other research at NPS.

a. Simkit

Simkit is a simulation engine designed by Lt. Kirk Stork in support of his thesis. [Ref. 13] Simkit continues to be developed by Dr. Arnie Buss as a tool for teaching event step simulation to Operations Research students at Naval Postgraduate School (NPS). Event step simulation centers around the notion of an event list as a master schedule. Events in the list are executed in the time sequence order. New events are scheduled and existing events are altered as necessary in the model.

The event list organization becomes a good method to organize the log files containing the position and event data recorded on the HPCs by exercise observers. The event list uses the GPS times to maintain playback order and also provides the mechanism to animate unit actions and interactions in terms of addition graphics displays.

b. Thistle

CPT Norbert Schrepf, a German Army officer, developed a set of components collectively called Thistle. [Ref.15] Thistle provides a fundamental distributed communication capability for all of the following components to share information in a simple fashion.

(1) ***Flora***

Thistle also provides a dynamic map and overlay display tool called Flora. Flora uses the common military maps available from the National Imagery and Mapping

Agency (NIMA) in digital form. Flora uses standard military symbols to display operational information over these maps. The symbols are simply implemented and appear in relation to geographic position, not image position, permitting scrolling and zooming of the map view. The geo referencing is accomplished with geo-coordinates (latitude and longitude) or the Military Grid Reference System (MGRS). Flora performs all updating of the unit locations as new positions are provided. Flora provides the flexible map display for TERES. An example of a Flora display was shown Figure 3.

(2) ***Briefing Tool***

Briefing Tool is a Thistle utility written by CPT Schrepf, and modified in the course of this work, to facilitate the animation of overlays for the map. Briefing Tool facilitates handling of military symbols as time sequenced series of overlays. The VCR-like controls in Figure 6 facilitate animation of the overlays with functions permitting backward and forward movement to any point in the overlay set. The tactical exercise data is processed into the format for replay through Briefing Tool.

(3) ***Grease Pen***

Grease Pen is a utility written by Dr. Gordon Bradley in response to a requirement from the project sponsor. Grease Pen primarily functions as a means to recreate military tactical operations graphics on the maps displayed in Flora. The proponent levied a requirement of a "John Madden Pen" to allow a "Monday Night Football" drawing over the replay of the tactical exercise. Grease Pen controls and overlays are displayed in Figure 7.

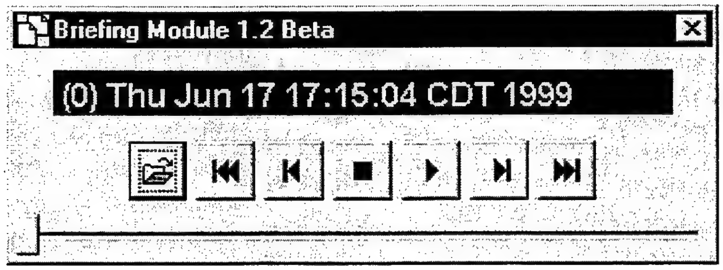

Figure 6. Briefing Tool controls.

Figure 7. Grease Pen controls and overlay.

Grease Pen takes advantage of the open source code and open design of Flora in a noteworthy way. Grease Pen was conceived long after Thistle and Flora were designed and implemented. Thistle's Message Center feature coupled with some Java functions permit the integration of Grease Pen seamlessly into the Flora utility on the screen without altering any of the original Flora or Thistle source code.

2. Software Design

The data processing consists of an event step methodology using Simkit. Simkit uses Discrete Event Logic that manages events on the basis of the time of each event's scheduled occurrence. Each log file is opened in turn and the first event from the file is posted to the event list. Log files can consist of exercising units, preplanned artillery targets, or imaginary units. These imaginary units are used to represent existence and location of enemy units or targets not represented by people during the exercise. This is a useful feature for live fire targets or when exercises lack enough participants to play the enemy.

The display subsystem uses Simkit's event list and the GPS Coordinated Universal Time (UTC) from each event, taken from the log file, to synchronize the data from multiple log files. When Simkit is started the earliest event on the list is executed. This event contains a reference to the source unit performing the event. Each event may require the movement of a unit or display of an interaction. The program maintains a master record of the current location of each unit and target participating in the model. After an event is executed, the source unit's current location record is updated and the next data record is read from the log file of that particular unit. The new data record is

then placed on the event list and Simkit determines the next appropriate event to execute based on recorded time.

Interaction log records alone do not contain enough information for display. A record from a direct fire engagement or an artillery mission on a preplanned target only contains the data concerning the unit initiating the action, the unit's location, and the subject of the action. The location of the subject of the action, another unit or artillery target, is unknown to each data recorder. When an interaction event is executed, the program will query the master record of unit locations for the last location of the subject of the action. If the action is artillery fire, then the master record of locations will return an entry from the "*.tgt" file provided in processing. If the action is a direct fire engagement then the master log return the location from the last event executed from that source. Location data on exercise participants is recorded every 15 seconds, providing sufficient resolution for all but the fastest of targets. If an attack is made on an entity before any data is recorded indicating its position then a warning will be issued during processing and no display of the event occurs.

V. SYSTEM OPERATION WITH ILLUSTRATIVE SCENARIO

An example exercise scenario was designed to demonstrate the operation and capabilities of the system put forward in this thesis. This scenario is based on the conduct of a company-sized force-on-force exercise. This exercise was staged on the grounds of Naval Postgraduate School on August 21, 1999 with students and faculty acting as friendly and enemy units.

A. EXERCISE SITUATION

1st Platoon, Company A, 1st Battalion, 1st Marines is located in an assembly area in vicinity of Glasgow Hall. An unidentified enemy infantry squad is located at the South-East corner of Del Monte Lake. 1st Platoon consists of three squads reinforced by Marines from Company A's weapons platoon. These reinforcements include M240 machine guns, M2HB machine guns, and Dragon anti-armor missiles. The Platoon Commander asked for three pre-planned artillery targets for responsive artillery support and was granted them.

B. UNIT MISSION AND LEADER'S CONCEPT OF THE OPERATION

The platoon commander for 1st Platoon has issued his order to the subordinate leaders as follows:

1. Mission

> On order, 1st Platoon will attack and destroy the enemy squad located in the vicinity of Del Monte Lake. 1st Platoon must be prepared to pursue the fleeing enemy unit or to repel a counterattack by a larger force from the North-East.
>
> Mission Statement from 1st Platoon Commander

2. Concept of the Operation

> I see the enemy's position next to Lake Del Monte as his weakness. We will attack with three squads abreast until all squads are along Phase Line "BOB". At Phase Line BOB I will initiate mortar fires to fix the enemy in their positions and then we will destroy them by fire from the heavy weapons. First and Third squads must be sure that individual enemy soldiers don't escape along the edge of the lake.
>
> 1st Platoon Commander's concept

C. DATA COLLECTION PLAN

The data collection plan was prepared in parallel with the plan of the unit exercising.

1. Controller Organization

On the day of this exercise four data collection subsystems were available for use. We also had the benefit of a group to role-play the enemy forces along with an exercise controller for each notional squad. The officer conducting the exercise decided to instrument the enemy role players and the three friendly squads with one data collection device each.

2. Tasks Recorded

The Data Playback subsystem supports the standard set of infantry unit tasks listed in Table 3. Since controllers' were available for this exercise, we used the full complement of tasks from the set.

Direct Fire	Indirect Fire
Fire	Immediate Suppression
Suppress	Adjust Fire
Shift	Fire For Effect
Cease	Repeat
	Grid

Table 3. Tasks supported by Data Playback system.

3. Preparation

The TERES hardware and software was initialized following the directions in Appendix E. The system had not been used in a week, causing a delay in the GPS receivers first fix time. After a delay of 10 minutes all of the GPS receivers had located their position. The resultant menus are shown in Figure 8. All observers were re-familiarized with the interface before the exercise began.

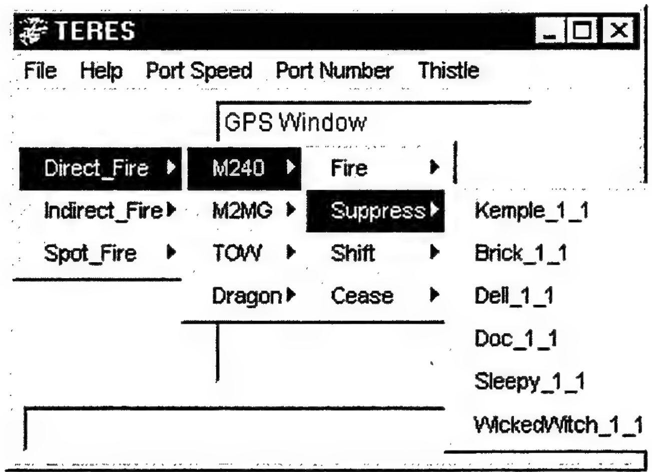

Figure 8. Data Recorder popup menus.

4. Exercise Execution

Individual controllers moved with their respective squads as the unit began the attack. Another controller moved with the enemy role players to the location of the enemy defense.

As the movement proceeded, the observers keep pace with their counterparts while the software automatically recorded locations. As the squads discovered the enemy locations, the observer positioned himself where he could best judge the actions of his counterparts.

The initial action by the first squad to discover the enemy was initiation of an artillery barrage upon a nearby preplanned artillery target. The observer heard this call being made over the radio since he had placed himself within earshot of the squad leader. The observer made an entry each time the squad leader called a mission.

Firing of the M240 machine guns and M2HB machine guns began as the remaining squads took up their positions to block the withdraw of the enemy unit. The observer recorded the identity of the enemy unit being fired upon from the menu choices when he heard the sound of firing and he had judged their efforts to be successful.

When the enemy role players heard the sound of blanks being fired from the attackers they noticed the positions of the attacking force and began returning fire. The observer with the enemy recorded the firing by his counterparts and entered the identity of the attacking units. He distinguished one opposing unit from the another by the observers' identities. Observers usually do not wear all of the combat equipment of exercise participants but do wear identifying marks such as white headbands to make them recognizable on the exercise battlefield.

These actions continued until the enemy was defeated, then the platoon prepared itself for a counter-attack.

5. Preparing for the AAR

After the exercising unit consolidated and the lead observer declared the problem finished, the exercising unit took inventory of their personnel and equipment. The observers gathered together and turned in their data collection devices.

The unit log files were transferred from each device in turn to a laptop computer. The lead observer processed the data following the steps in Appendix F. The observers all watched the data display during processing to get a preview of the action.

6. AAR Execution

After the processing was completed and the exercise leader had assembled his Marines, the head observer began a discussion of the exercise using the Briefing Tool, following the instructions in Appendix G. Focus was placed on the leader's actions and decisions while TERES provided an overview of the battle. Figure 9 shows a display of how the screen looked. The Platoon Commander had an opportunity to see how well his plan supported the mission as it unfolded. The Squad Leaders discussed the plan, the decisions made by the Platoon Commander, and how they could be improved or more effectively communicated. The Platoon Commander questioned if there was sufficient flexibility in his plan to adapt to a changing situation. Each subordinate saw a graphical depiction of the plan along with the unit's execution of the mission. Each individual witnessed how their efforts fit into the task as a whole.

At the conclusion of the AAR each member of the unit walked away with real understanding of what was accomplished. Strengths were reinforced and the causes of mistakes were better understood to reduce the chance of repeating them on the next exercise or in combat.

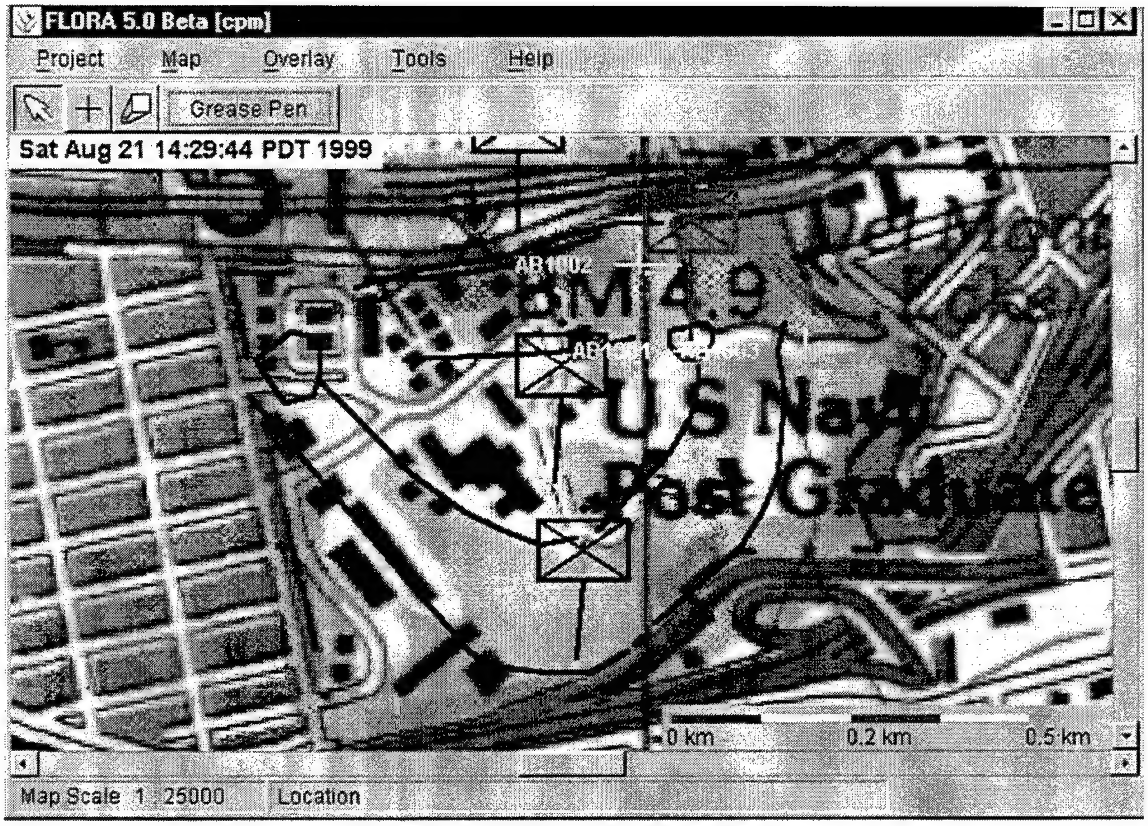

Figure 9. TERES AAR playback.

VI. THE NEXT LEVEL

This system is designed with generality and extensibility in mind. Several subjects emerged as areas for improvement or further development.

A. GENERIC PLAYBACK

The data collection subsystem is written in a manner making it possible to reprogram the interface and menu system to capture a variety of tasks with location and time information. The data playback system is not able to display all types of data collected, but is specifically designed to display position reports and tactical battlefield activities described in this thesis.

The display subsystem could be enhanced to permit generic playback. An API could be specified for different graphical depictions and associations could be made between selected data and its depiction on the map. Graphical depictions could be lines, shape, or shadings. The display software should not be dependent upon the data collection software for its function.

B. INCREASED INSTUMENTATION RESOLUTION

TERES currently depends on observers to record task performance. The distributed data collection approach is extensible and could be integrated with other training aids such as the Multiple Integrated Laser Evaluation System 2000 (MILES 2000). MILES 2000 consists of weapon mounted lasers and body or vehicle mounted sensors designed to enhance training realism by indicating to an individual or crew when they are being shot at and with what effect. MILES 2000 records shooter and target

information to provide a tabular printout for feedback to exercise participants after completion of an exercise.

The MILES 2000 system could be integrated with TERES and high-resolution exercise data could be passively collected while Marines use their weapons. A coupling of both systems collecting higher resolution data for immediate graphical review should not be difficult. A dynamic portrayal of MILES 2000 data is much more useful than a printed record of engagements. Joining MILES 2000 together with TERES would achieve the majority of requirements in the original RIS ORD.

C. PERFORMANCE ANALYSIS

Measurement of unit performance is always a controversial issue in military circles. TERES could be easily altered to compile and present descriptive statistics for unit performance evaluations, doctrinal tests, or equipment test. Associations between target appearance and target engagement by a weapon or unit is easily included through features available in Simkit. Other statistics may also be usefull.

D. REAL TIME DISPLAY AND ANALYSIS

The strategic choice of Java as a programming language provides the added benefit of easy expansion onto a digital network. In the course of this research there were several excursions into experiments with wireless networks. Java includes features which make network operation simple and efficient. The small size of the position and activity reports written to the "*.log" files could easily be handled by a wireless network. Scalability testing for large exercises would be necessary. Techniques for dealing with the problem of data arriving out of order at different points also must be developed.

E. BATTLEFIELD AWARENESS TOOLS AND TACTICAL DECISIONMAKING AIDS

The development of TERES into a common and familiar training aid could be combined with improvements in wireless digital networks to develop aids for the tactical decision-maker. The skeptical consumer often only accepts the burden of a new tool when its value has been demonstrated. Digital support on the training battlefield will spawn acceptance of battlefield awareness tools and tactical decision aids. The functionality of these tools can be developed from successful training aids with minimal experimentation and maximum acceptance.

VII. CONCLUSIONS

TERES has the potential to enhance development of tactical judgement and skills of all Marines conducting tactical training. Display of the spatial information dynamically with common military maps and symbols permits immediate recognition of the data and reinforces the use of these mediums as planning tools. The objective baseline established by this system enables frank and professional discussion of unit and individual performance in a framework of the battlefield functions.

This low-cost, distributed data collection approach provides excellent resolution that meets exercise participants' needs for training feedback. The technology for a simple distributed data collection and geographic display system using commercial-off-the-shelf computers and GPS receivers to provide immediate support and timely feedback for exercise participants is available. TERES demonstrates an architecture and implementation of such a system.

The data collection subsystem and the display subsystem execute without change on any computer that fully implements the Java Virtual Machine (JVM). The JVM implementation for the WindowsCE operating system does not fully implement Java Native Interface (JNI) which enables serial communication with the GPS. Full functioning of this system on a WindowsCE device requires additional coding.

Full Java virtual machines for HPCs and PDA's are currently being developed and tested. APIs for software development on these platforms are already available. [Ref.16] The HPC and PDA continue to grow in power and shrink in size and cost.

When these small devices become integrated with developing wireless technology, this exploding segment of the commercial digital computing marketplace will serve to exceed our expectations for RIS by evolving into battlefield awareness tools and decision aids.

APPENDIX A. GPS DATA FIELDS

Example	Field Name	Description
$GPGGA	Type	Type of NMEA sentence
180312	UTC	UTC time stamp Hours:minutes:seconds
3400.000	Latitude	Latitude in DDDMM.mmm format
N	Latitude Compass	N or S representing indicating hemisphere
06854.375	Longitude	Longitude in DDDMM.mmm format
E	Longitude Compass	E or W indicating hemisphere
1	Signal Quality	0 no fix 1 GPS fix 2 Differential GPS fix
08	Satellite Use Count	Number of satellites used to calculate position
2.0	Horizontal Dilution Precision	A measure of inherit uncertainty in latitude and longitude measure
151.6	Altitude	Altitude above mean sea level
M	Altitude units	Unit of measure usually meters
-131.5	Geoidal Separation	A measure of displacement from an imaginary perfect spheroid around the earth
M	Geoidal Separation Units	Unit of measure usually meters
(can be empty)	Differential Data Age	Age of last differential correction signal
(can be empty)	Differential Station ID	ID of station generating differential signal
*76		CRC character

APPENDIX B. OPERATIONAL REQUIREMENTS DOCUMENT FOR RIS

1. General Description of Operational Capability

a. Mission Area. This requirement relates to Mission Area 11, Command and Control (C2). The Marine Corps Master Plan for the 21st Century dated 8 October 1997, Goals G and H pertain as follows: "Modernize training and education through advanced technologies" and "Develop and use distributed simulation technologies to enhance training and operations." Required Operational and Support Capabilities R.20, "Incorporate simulation, instrumentation, and automation into training range upgrades" and R.21, "Exploit emerging training and education technology" also pertain.

b. System Description. The Range Instrumentation System (RIS) will equip Marines, their weapon systems and vehicles with instrumentation equipment. This will provide the data necessary to automatically track and report their position and status back to a computerized operations center in near real time. RIS will draw fire engagement and position data from individuals, vehicles and weapons and integrate this with other instrumentation systems and computer generated forces to expand the size, scope, and realism of a given training evolution. RIS will initially be restricted to fixed site training ranges, but must be upgradeable to a deployable capability. It will ultimately merge with the developing tactical instrumentation to provide an embedded training capability within a tactical instrumentation system.

c. Operational Concept. RIS will enable Marines to train more effectively by supporting near real time adjudication of engagements during force on force training. It will also provide near real time interaction between Marines and computer generated forces. Both force on force and live fire training will make use of targets with instrumentation and computer generated forces. RIS will also provide enhanced after action review of each training evolution. RIS must support all Marine Air Ground Task Force (MAGTF) operations. RIS will be capable of operating under varied terrain and weather consistent with normal training areas.

d. Support Concept. Operational and maintenance support will be provided by a contractor.

e. Mission Need Statement (MNS). MNS number TNG 1.30 for Marine Corps Modeling and Simulation Centers, dated 23 April 1996, validated the requirement for RIS.

2. Threat. RIS is not designed to counter any specific threat; it is designed to enhance current training capabilities.

3. Shortcomings of Existing Systems. The Marine Corps does not currently possess a RIS capability. Existing systems currently in place on other Service ranges are of no use to the Marine Corps. Elements of those systems and lessons learned by other Services will be utilized during the development of RIS.

4. Capabilities Required

a. System Performance. Unless otherwise stated below, reference to Marines, their weapons and vehicles is intended to mean those equipped with instrumentation.

(1) Mission Scenarios. RIS will enable Marines to realistically interact with each other, with targetry and with computer generated forces during both force on force and live fire training evolutions.

(a) Ground-Ground (Direct fire). Forces can engage each other with Multiple Integrated Laser Equipment System (MILES) equipped direct fire weapon systems. Marines can also be engaged by computer generated forces through the RIS in both force on force and live fire exercises. Instrumented targets representing the computer generated forces will add realism by initiating engagements and by recording hits and near misses.

(b) Ground-Ground (Indirect fire). Marines can engage each other or targets through the RIS with indirect fires. Fires originating either from an actual or computer generated indirect fire weapon system will add realism to training. Simulated area weapons effects (SAWE) emitters and detectors will be integrated with MILES gear.

(c) Air-Ground. Fixed and rotary wing aircraft can engage Marines through the RIS by performing no drop bomb scoring and air-to-ground gunnery within an aviation instrumentation system. The results are then passed to the RIS for adjudication and dissemination to the forces on the ground.

(d) Ground-Air. Fixed and rotary wing aircraft can be engaged by ground based air defense weapon systems integrated into the aviation instrumentation system.

(e) Air-Air. Aircraft can engage each other within the confines of aviation instrumentation systems.

(f) Surface-Ground. Ships can engage Marines through the RIS by performing no shoot naval gunfire support within the maritime instrumentation system. Results from these simulated fires are then passed to the RIS for adjudication and dissemination to the forces on the ground.

(2) Employment Tactics. RIS will be employed during force on force and live fire training.

(3) Environmental Conditions. RIS must be capable of operation and maintenance in normal training areas.

(4) Parameters

(a) RIS must provide instrumentation for individual Marines and the Marine weapon systems identified in paragraph 6, Force Structure. Instrumentation must readily mount on individual Marines, weapons and vehicles. The instrumentation will require no permanent or disruptive modification and must not interfere with normal functioning and operations.

(b) Complete instrumentation packages for individual Marines will weigh less than six pounds (threshold) and two pounds (objective). Equipment will operate for at least 72 hours (threshold) and 120 hours (objective) on a single rechargeable battery. It will not interfere with movement any more than the individual combat load. Optimally, individual instrumentation would be integrated into the individual load bearing equipment.

(c) RIS must provide automated, near real time, two way, data communication between Marines and the operations center in support of the following interactions:

1 RIS must provide position information on Marines to the operations center. Spherical error probable of position information must be less than one meter.

2 RIS must draw direct fire status and engagement data from Marines MILES equipment and pass it on to the operations center. SAWE data must be similarly passed for indirect fires.

3 RIS must be able to communicate direct and indirect fire engagement data to Marines equipment based on centrally adjudicated engagements.

4 RIS must enable Marines to interact with participants in other instrumentation systems such as those identified in paragraph 5h, Standardization, Interoperability, and Commonality.

5 RIS must enable Marines to interact with computer generated forces such as those identified in paragraph 5h, Standardization, Interoperability, and Commonality.

6 RIS must provide Marines with appropriate battlefield audio and visual cues of the positions and actions of computer generated targetry.

7 RIS must support the preceding interactions during both force on force and live fire training. It must accommodate all forms of terrain found in current training areas (urban, mountain, foliated, desert, riverine, etc.) under all environmental conditions.

8 RIS must provide after actions review (AAR) of each training evolution both at the operations center and in the field. The AAR in the field will provide the small unit leader with a "hot wash" immediately after the specific training evolutions has taken place. This will illustrate errors made in training and also reinforce positive learning points. The formal AAR will provide an overall, objective status of each training event. It will provide the basis for judgments concerning the combat readiness of the unit. Finally, a "take away" AAR will provide the basis for subsequent training.

b. Logistics and Readiness

(1) Reliability. Mean Time Between Failure must be at least 200 hours (threshold) and 336 hours (objective) during two weeks of continuous operation. Rarely will the

requirement exist for an excess of five days of continuous operation. Most training evolutions are of shorter duration.

(2) Operational Availability. Operational viability must be at least 95 percent during training evolutions. The system must be capable of continuing to collect and process data even during periods where elements are taken off-line for maintenance of hardware, software and databases.

(3) Maintainability. Support contractor will perform all preventative maintenance during non-operational periods. Support contractor will perform all corrective maintenance, and Mean Time To Repair must be less than two hours (threshold) and one hour (objective).

c. Combat Identification. RIS does not require a combat identification capability.

5. Program Support. The Joint Potential Designations are: U.S. Army (joint), U.S. Navy (joint interest), and U.S. Air Force (joint interest).

a. Maintenance Planning. All maintenance support will be provided by a support contractor.

b. Support Equipment. RIS must be delivered with all support equipment and spares required for the support contractor to perform necessary maintenance.

c. Human Systems Integration (HSI). This system is intended to utilize Commercial Off the Shelf (COTS) hardware so it is not anticipated that the HSI will be any greater than that encountered with any other system.

(1) Manpower Constraints. All operational and maintenance support will be provided by a support contractor.

(2) Training Concept. Support contractor will provide all necessary training each time equipment is issued to users.

(3) Safety. RIS must meet all applicable safety regulations. RIS hazards identified as Category I or Category II in accordance with MIL-STD-882C shall be eliminated or reduced to an acceptable level. The RIS shall avoid the use of toxic chemicals, hazardous materials, ozone depleting substances and manufacturing processes that will have a detrimental impact upon the environment during acquisition and its related operational support.

(4) Human Engineering. RIS shall be user-friendly. The design shall consider ease of use and minimize the skill needed for operation and maintenance. A qualitative assessment of the man-machine interface based on the judgment of the operators, maintainers, and human factors experts must be done. Design of the RIS shall include these human factors:

(a) No components should restrict operator activity or present an unsafe situation. Warning labels and indicators must be used to warn of potential human hazards.

(b) Components must be easy to operate and maintain.

(c) Cables must be labeled and easy to connect and disconnect.

(d) Users dressed in cold weather or chemical protective clothing shall be able to use the system.

(e) Controls and displays shall be easy to locate. Visual indicators shall be readable in all light conditions. Displays shall be adjustable for varying light conditions.

(f) Provide carrying cases for mobile equipment. The carrying case shall be waterproof from rain, snow, and sleet. Waterproofing does not entail submersion.

(g) Use a consistent graphic user interface (GUI).

(h) Provide easy to read manuals and help files.

d. Computer Resources. RIS should use COTS hardware wherever feasible.

e. Other Logistics Consideration. Development contractor must identify facility and shelter requirements for each training range.

f. Command, Control, Communications, Computers, and Intelligence (C4I). While initially a fixed system, RIS must be capable of importing and exporting data with tactical systems as they evolve. As such, RIS must be compliant with Department of Defense (DoD) approved system integration protocols. RIS must be interoperable with aviation instrumentation systems (e.g., Joint Tactical Combat Training System (JTCTS), the Tactical Air Combat Training System (TACTS), the Large Area Tracking Range (LATR)). It must also interface with maritime instrumentation system such as the Shallow Water Tracking Range (SWTR). RIS must also be interoperable with the Joint Simulation System (JSIMS), or a designated DoD approved high level simulations systems architecture. RIS must be designed to utilize legacy systems as components whenever possible.

g. Transportation and Basing. RIS will operate in already utilized training areas. The development contractor will provide facilities engineering operating agencies with additional data to modify already requested military construction (MILCON). Subsystems of the deployable RIS, when developed, will be capable of transportation by truck, rail, aircraft and amphibious shipping.

h. Standardization, Interoperability, and Commonality. The RIS will be in compliance with all applicable standards within the DoD Joint Technical Architecture (JTA). It must include, but not be limited to information processing, information transfer, and human computer interface standards. Standard commercial power (AC, 110v, 60 Hz) will be used because of the static nature of RIS in its initial configuration. Electromagnetic band necessary to support RIS is yet undetermined. The deployable RIS subsystems will operate with normal mobile electric power.

i. Mapping, Charting, and Geodesy Support. RIS must use National Imagery and Mapping Agency (NIMA) standard digital products in accordance with DoD directive 5105.60. RIS will require Compressed ARC Digitized Raster Graphics (CADRG) at 1:1250, 1:2500, 1:12500, 1:25K, 1:50K, 1:100K, and 1:250K for plan view visualization of forces. RIS will also require Digital Terrain Elevation Data (DTED) with one meter postings and feature data with a corresponding level of detail to support interaction of instrumented Marines with computer generated forces.

j. Security. RIS must comply with current requirements and be capable of evolving to meet state-of-the-art technological advances designed to protect information from unwanted exploitation as imposed by national, DoD, and joint policy. RIS must be protected from an Information Systems Security (INFOSEC) perspective, which would include, but not be limited to, such services as confidentiality, availability, and integrity of information that is either processed, stored, or transmitted. RIS will not process or hold classified material.

k. Environmental Support. The RIS operations center will require an environmental control system (ECS). Field operating elements of the RIS will require no ECS. RIS produces no hazardous or controlled byproducts except for batteries.

6. Force Structure

	1st RIS Camp Lejeune NC	2nd RIS MCAGCC 29 Palms CA	3rd RIS Camp Pendleton CA	4th RIS MCCDC Quantico VA
Player Detection Devices				
with M16 Small Arms	1800	2450	1800	360
Direct Fire Weapon Systems				
M249	114	171	114	54
M240G	81	140	81	24
M2	14	21	14	4
Mk19	21	28	21	4
SMAW	28	50	28	12
AT-4/Dragon/Predator	68	100	68	24
TOW	12	26	12	4
Vehicle Detection Devices				
HMMWV	125	147	125	20
M1A1	14	41	14	0
AAV	46	33	46	12
LAV	24	110	24	12
5 Ton/LVS	25	42	25	12
Targets				
Infantry	370	700	370	150
Vehicle	60	300	60	10
Indirect Fire Weapons				
60 mm Mortar	18	27	18	6
81 mm Mortar	6	9	6	3
M198	16	24	16	2

Mines						
AntiPersonnel		200		400	200	40
AntiTank		100		200	100	20
Grenades		200		400	200	40
Air Defense Weapons		20				
Stinger		10		40	20	10
Avenger		10	20	20	10	4
LAV-AD					10	4
Aviation Instrumentation	AH-1					
UH-1		4		8	4	1
CH-46	CH-53	2		4	2	1
F/A-18		12		24	12	2
AV-8B		4		8	4	1
MV-22		12		24	12	2
		16		32	16	6
		12		24	12	2

7. Schedule Considerations

a. Initial Operational Capability (IOC). IOC is achieved when the first RIS is fully operational at Camp Lejeune, North Carolina.

(1) IOC. FY03.

(2) Impact if IOC is Not Met. The Marine Corps does not currently possess a RIS capability and has no way to objectively assess collective training performance. Until IOC is achieved, the Marine Corps will not have the ability to bridge and measure training effectiveness at the unit level.

b. Full Operational Capability (FOC). FOC is reached when the fourth RIS is fully operational at Marine Corps Combat Development Command, Quantico, Virginia.

(1) FOC. FY09.

(2) Impact if FOC is Not Met. Until FOC is achieved, many Marine Corps units will be unable to conduct instrumented training.

APPENDIX C. SOURCE CODE FOR NMEAPOSITIONSTATUS OBJECTS

```
package serialDebug;
import java.util.Date;

/**
*
* Meant to contain positioning information received from
* a GPS or other NMEA-compliant device
*/

public class NMEAPositionStatus
{

public long UTC = 0;
//the current time coordinate if available (0 otherwise)
//( will be parsed from "hhmmss.ss" where ".ss" is of
//variable length)

public double longitude = 0;
//degrees latitude parsed from: "DDMM.ddd'" where "ddd" is
of
//variable length

public boolean longitudeCompass = true;
// true for East, false for West

public double latitude = 0;
//degrees latitude parsed from: "DDMM.ddd'" where "ddd" is
of
//variable length

public boolean latitudeCompass = true;
// true for North, false for South

public double altitude = 0;
//height above mean seal level in Meters

public float geoidalSeparation = 0;
//height of mean sea level above WGS-84 earth ellipsoid,
//in meters

public float horDilPre = 0;
//horizontal dilution of precision
```

```
//same as GDOP except elevation is ignored all geometric
//factors that degrade the accuracy of a position fix"

public byte signalQuality = 0;
//how good is the data we're receiving? (GPS only)
//(0: fix not availible,
//1: GPS fix,
//2: Differential GPS fix)

public byte satelliteUseCount = 0;
//how many satellites are we using? (GPS only)
// (range 0...12)
public int diffDataAge = 0;
//time since last differential GPS correction, in seconds
//(diff GPS only)

public String diffStationID = "void";
//uniqueID of differential reference station,
//range 0000 to 1023
//(diff GPS only)


/**
* Overrides Object.toString
* Generates a string representation of the object
*/
public String toString()
{

    String UTCstr = "TIME: " + (new Date(UTC)).toString();
    String lonStr = "LON: " + longitude +
                        (longitudeCompass ? " E " : " W ");
    String latStr = "LAT: " + latitude +
                        (latitudeCompass ? " N " : " S ");
    String altStr = "ALT: " + altitude + " M " +
                    " Geoidal Separation: " +
                    geoidalSeparation;
    String qualStr = "Signal Quality: " + signalQuality +
                    " Satellites in Use: " +
                    satelliteUseCount +
                    " horDilPre: " + horDilPre +
                    " Diff. Data Age: " + diffDataAge +
                    " diffStationID: " + diffStationID;

    return      "\n" +
```

```
        UTCstr + "\n" +
        lonStr + "\n" +
        latStr + "\n" +
        altStr + "\n" +
        qualStr + "\n";

    }//toString

}//NMEAPositionStatus
```

APPENDIX D. SAMPLE DATA COLLECTION SUBSYSTEM OUTPUT

Posrep, , ,38.51793333333333,N,77.3363,W,Thu Jun 24 05:07:33 PDT 1999,4
Posrep, , ,38.518,N,77.33636666666666,W,Thu Jun 24 05:07:51 PDT 1999,4
Posrep, , ,38.518066666667,N,77.336466666667,W,Thu Jun 24 05:08:09 PDT 1999,4
Posrep, , ,38.518133333333,N,77.336616666667,W,Thu Jun 24 05:08:27 PDT 1999,4
Posrep, , ,38.5181833333333,N,77.3368166666666,W,Thu Jun 24 05:08:45 PDT 1999,4
Posrep, , ,38.5182333333335,N,77.3370166666667,W,Thu Jun 24 05:09:03 PDT 1999,4
Posrep, , ,38.51826666666667,N,77.3372,W,Thu Jun 24 05:09:21 PDT 1999,4
Posrep, , ,38.5182666666667,N,77.3373166666667,W,Thu Jun 24 05:09:39 PDT 1999,4
Posrep, , ,38.5182833333336,N,77.3374166666667,W,Thu Jun 24 05:09:57 PDT 1999,4
Posrep, , ,38.51828333333336,N,77.337483333334,W,Thu Jun 24 05:10:15 PDT 1999,4
Posrep, , ,38.5182833333336,N,77.3375166666667,W,Thu Jun 24 05:10:33 PDT 1999,4
Posrep, , ,38.51825,N,77.3375,W,Thu Jun 24 05:10:51 PDT 1999,4
Posrep, , ,38.518183333333,N,77.33733333333333,W,Thu Jun 24 05:11:10 PDT 1999,4
Posrep, , ,38.51816666666666,N,77.337033333334,W,Thu Jun 24 05:11:28 PDT 1999,3
Posrep, , ,38.51828333333336,N,77.336783333333,W,Thu Jun 24 05:11:46 PDT 1999,3
Posrep, , ,38.51845,N,77.33666666666667,W,Thu Jun 24 05:12:04 PDT 1999,3
Posrep, , ,38.5185,N,77.33665,W,Thu Jun 24 05:12:22 PDT 1999,3
Posrep, , ,38.5185666666665,N,77.3366666666667,W,Thu Jun 24 05:12:40 PDT 1999,3
Posrep, , ,38.518683333333335,N,77.33665,W,Thu Jun 24 05:12:58 PDT 1999,3
Posrep, , ,38.51885,N,77.3366,W,Thu Jun 24 05:13:16 PDT 1999,3
M240,Fire,EnemyPos2_1_1,38.51885,N,77.3366,W,Thu Jun 24 05:13:16 PDT 1999,3
Posrep, , ,38.518966666666664,N,77.33655,W,Thu Jun 24 05:13:35 PDT 1999,3
TOW,Hit,EnemyPos2_1_1,38.51901666,N,77.3365,W,Thu Jun 24 05:13:47 PDT 1999,3
Posrep, , ,38.51905,N,77.33646666666667,W,Thu Jun 24 05:13:53 PDT 1999,3
Posrep, , ,38.519166666666,N,77.33641666666666,W,Thu Jun 24 05:14:11 PDT 1999,4
M2MG,Fire,EnemyPos2_1_1,38.5192,N,77.336316,W,Thu Jun 24 05:14:27 PDT 1999,4
Posrep, , ,38.51926666666667,N,77.3363,W,Thu Jun 24 05:14:29 PDT 1999,4
M240,Fire,EnemyPos2_1_1,38.51936,N,77.336183,W,Thu Jun 24 05:14:41 PDT 1999,3
Posrep, , ,38.5193,N,77.33615,W,Thu Jun 24 05:14:47 PDT 1999,3
M240,Fire,EnemyPos2_1_1,38.51926,N,77.336167,W,Thu Jun 24 05:14:51 PDT 1999,4
M2MG,Fire,EnemyPos2_1_1,38.51925,N,77.3361,W,Thu Jun 24 05:15:03 PDT 1999,3
Posrep, , ,38.51925,N,77.33608333333333,W,Thu Jun 24 05:15:05 PDT 1999,3
Artillery,Immediate_Suppression,AB1002,38.5,N,77.3,W,Thu Jun 24 05:15:11 PDT 1999,3
Posrep, , ,38.51923333333,N,77.33603333333333,W,Thu Jun 24 05:15:23 PDT 1999,3
M240,Fire,EnemyPos1_1_1,38.5192165,N,77.33605,W,Thu Jun 24 05:15:39 PDT 1999,4
Posrep, , ,38.5192,N,77.33605,W,Thu Jun 24 05:15:41 PDT 1999,4
Posrep, , ,38.519216666666665,N,77.3360333333,W,Thu Jun 24 05:15:59 PDT 1999,3
Posrep, , ,38.51925,N,77.3361,W,Thu Jun 24 05:16:17 PDT 1999,4

APPENDIX E. DATA COLLECTION DEVICE OPERATION

Operation of the Data Collection device is easy once it is properly initialized. Once the computer is turned on, attach the GPS. The data collection software cannot be started until the GPS has acquired sufficient satellites to plot current location. The data collection software is executed from the command line with:

"java DataRecorder.PopupShowTest."

On execution of the code, the user interface shown in Figure 10 appears. First initialize the software for the port number that connects the GPS to the computer. The port speed must match the configuration of the GPS. The GPS setup menu or the GPS manual will indicate the port speed setting.

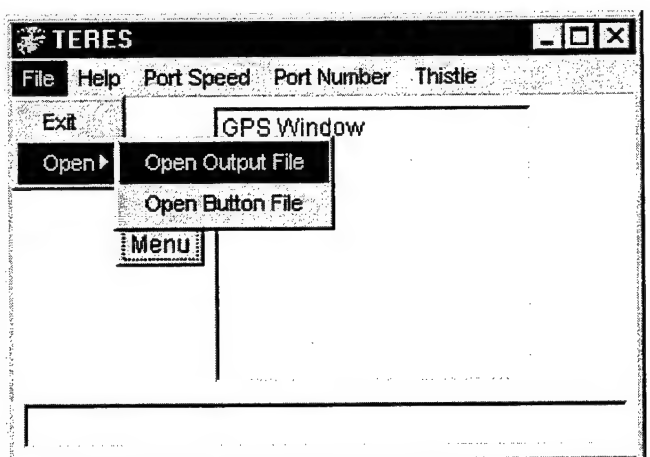

Figure 10. Data Recorder interface.

After the GPS connection is confirmed, the Output File must be set. The location of the output file is not important unless you want to make use of the data synchronization features available on many HPC's. The name of the output file is critical. The output file name determines the type and appearance of the map icon that will represent the unit. The default unit color is blue. Starting the file name with the

word "Enemy" changes the unit color to red. The file name also includes some numbers separated by underscore characters. These numbers determine unit type and unit size. Table 4 displays permissible entries for these fields. The filename "EnemyPlatoon_1_3" indicates an enemy infantry platoon. No file extension is required. After the Output File is entered the system will begin to read the GPS data and record positions automatically.

NUMBER	UNIT TYPE	UNIT SIZE
1	Infantry	Section
2	Tank	Squad
3	Mechanized Infantry	Platoon
4	Artillery	Company

Table 4. Unit symbol type and size codes for unit log filenames.

The menu must be initialized if recording of METL tasks is desired. The system will collect and record position data automatically with or without this entry. The tasks must be entered in a manner indicating their hierarchy. The target names in the menu initialization file must match the file names of the Output Files for proper functioning of the system. Figure 11 shows the menus with target choices exposed. If the menu disappears from the top of the desktop, pressing the menu button will make it reappear.

The popup menus function identically to the ones common on desktop software. The selection of weapon type, weapon action, and finally, target, writes an event to the unit log file which is accompanied by a time and location from the GPS. These action

events are recorded chronologically with the passive position recording of each Data Collection subsystem. An example of one unit's log file is included in Appendix D.

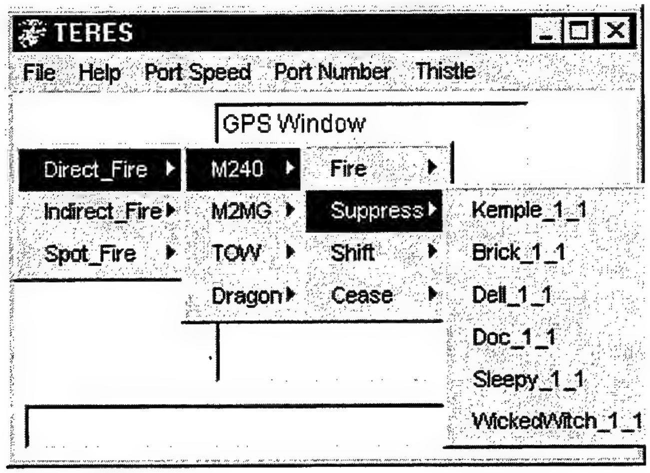

Figure 11. Data Recorder menu display.

APPENDIX F. DATA ASSEMBLY AND PROCESSING

At the conclusion of the tactical exercise, the software is closed from the menu on the user interface running on each device. All devices must be collected from the controllers and their unit log files transferred to one desktop or laptop computer for processing before the AAR. The files may be transferred by floppy disk in the case of notebook computers or by synchronization cable in the case of HPCs.

After the data is assembled, the processing software is opened. Since the software is integrated with Thistle, the first step is to execute Thistle with the command "java thistle.Thistle." Once the Thistle toolbar shown in Figure 12 appears on the display, press the button for the map.

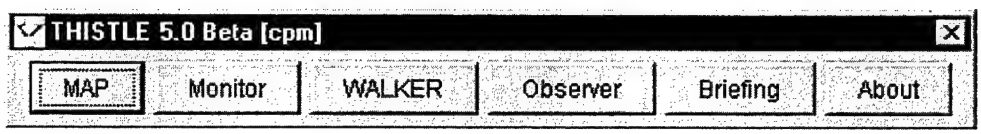

Figure 12. Thistle Toolbar.

After selecting the Map button the Flora map display shown in Figure 3 will appear. Press the Grease Pen button on the Flora menu bar if operations graphics are used in the exercise. Figure 13 shows the operations graphics used in a scenario.

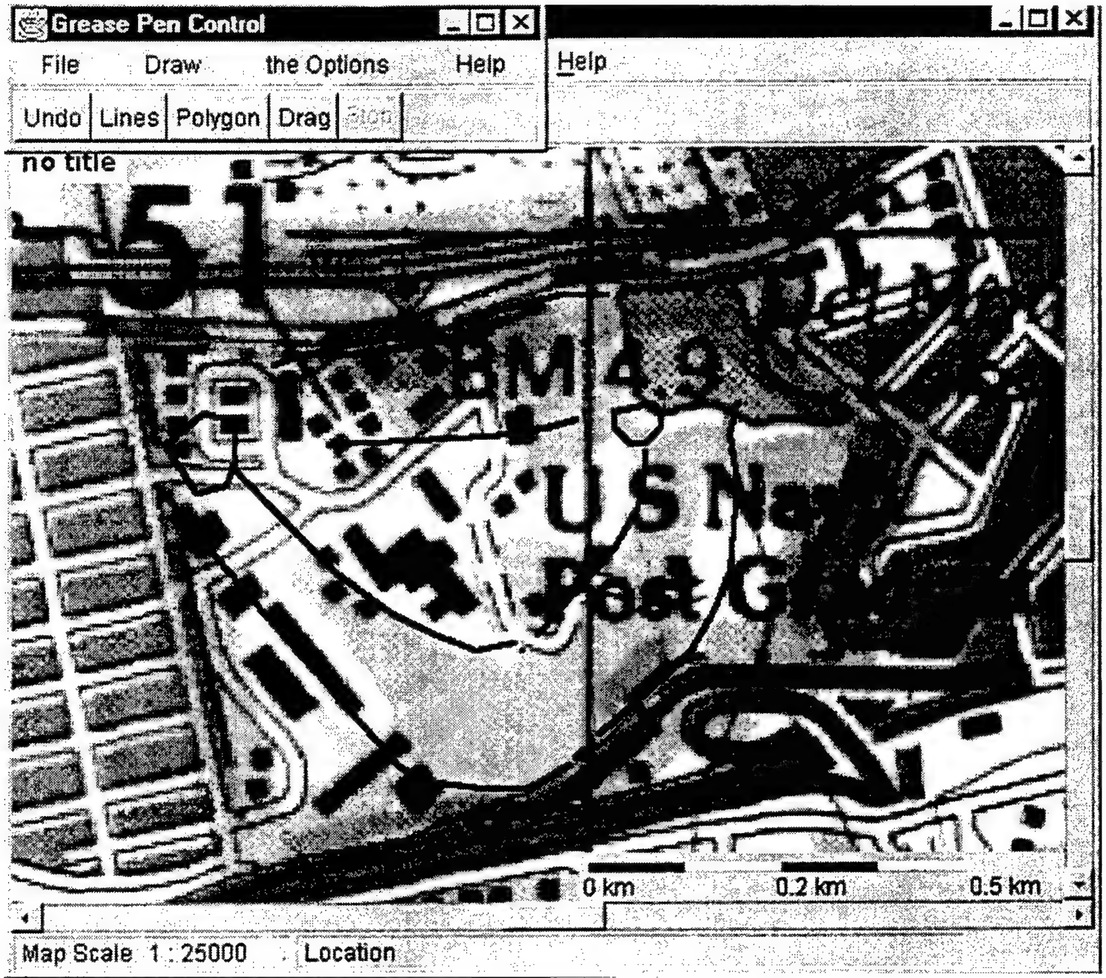

Figure 13. Flora map with operations graphics in blue.

Processing unit log files into a format for review requires three steps for preparation. After pressing the button labeled “Observer” on the Thistle toolbar in Figure 12, the Observer program for processing will launch. Observer will open with a dialog box as shown in Figure 14. The first step in preparing to process is to name a “show” file. These files have the extension “*.show.” This file will be accompanied by a large

number of related files created during processing and is best placed in a directory of its own.

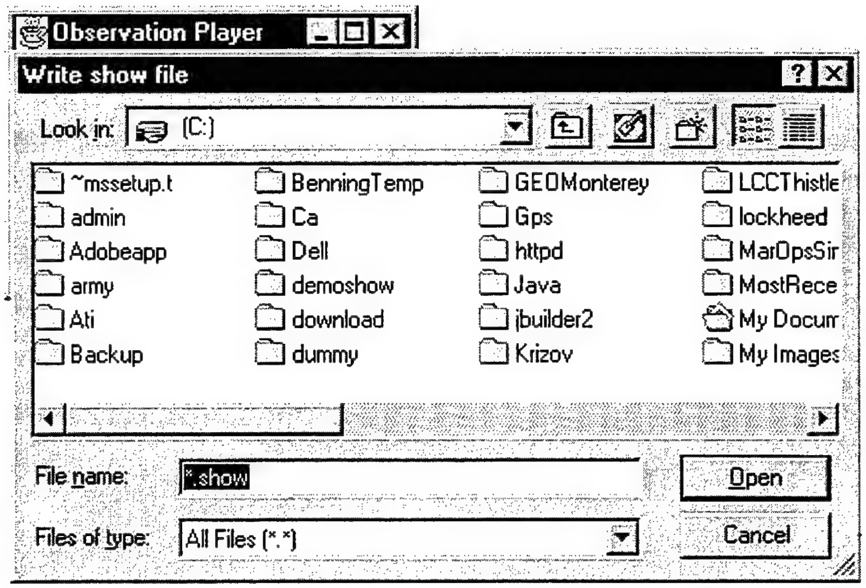

Figure 14. Observer user interface accompanied by "show" file dialog box.

After the show file is entered a second dialog box opens prompting the user for a "*.tgt" file, see Figure 15. This file contains the pre-planned artillery targets requested by the Platoon Commander. Typical entries for this file are shown in Table 5.

AB1001,38.5191667,N,77.3352778,W
AB1002,38.5194444,N,77.33778,W
AB1003,38.5213889,N,77.33778,W

Table 5. Typical contents of "*.tgt" fire support overlay file.

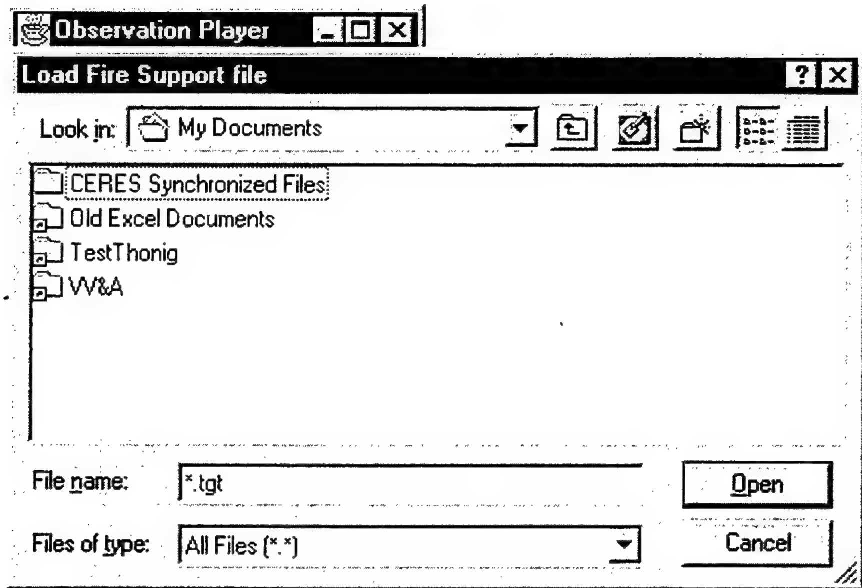

Figure 15. Observer interface with accompanying "target" file dialog box.

After the show and target files have been entered, the unit log files are entered. A dialog box shown in Figure 16 will automatically appear prompting unit log file entry. Once all of the unit log files have been entered, press "Cancel" on the dialog box and the Observer software will be ready to run.

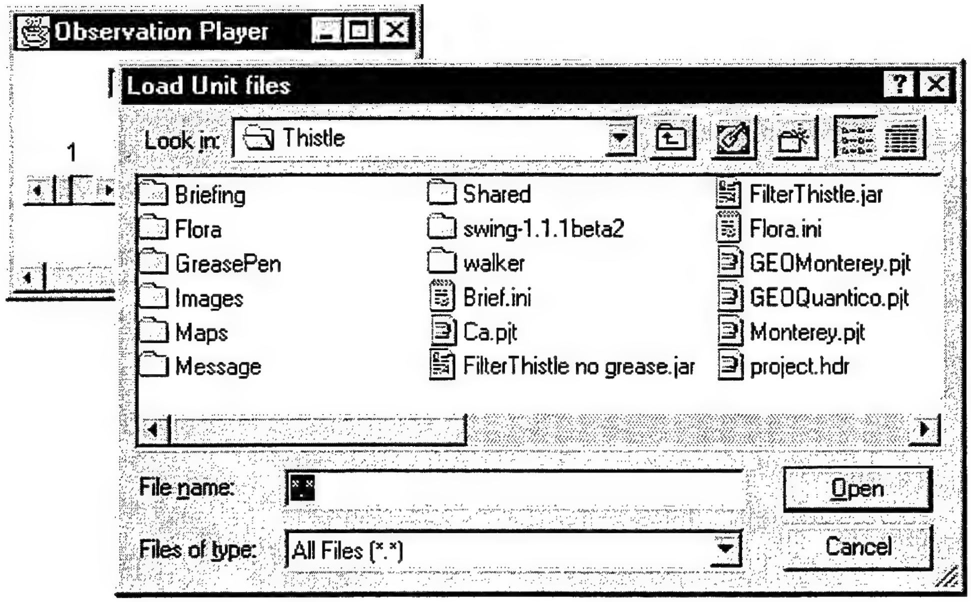

Figure 16.. Observer interface with unit file dialog box.

Now that the software is initialized, the Observation Player interface, Figure 17, is used to process the exercise data into a model for presentation with the Briefing Tool. The map is available for viewing of activities while the processing is underway and the user interface has controls for pausing or adjusting processing speed. The processing procedure cannot be rewound during processing. After the processing is complete, the Observer software can be closed.

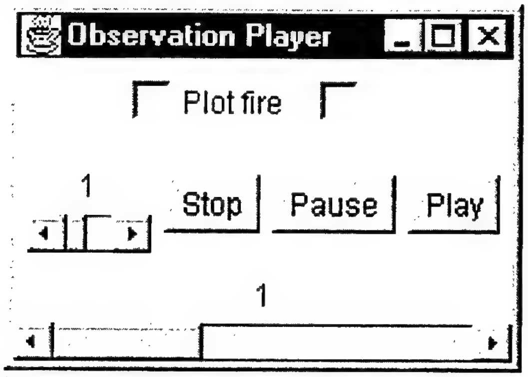

Figure 17. Observation Player interface.

APPENDIX G. EXERCISE PLAYBACK

Exercise playback is simple and intuitive. The Thistle Briefing Tool is designed with the simple, familiar VCR controls shown if Figure 18. A slider bar has been added to the VCR controls. The slider bar allows the user to move quickly to any part of the exercise play back. This feature is helpful when examining a particular portion of the exercise. By clicking and dragging the slider bar the user can move through uninteresting portions of the data and focus on AAR relevant material.

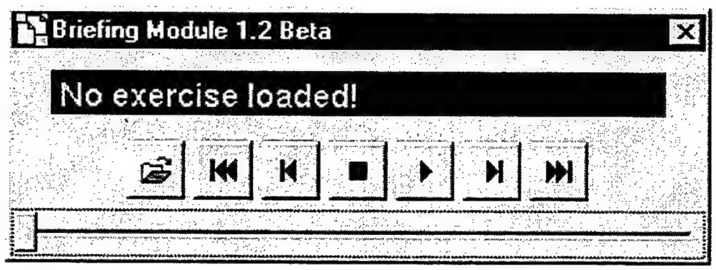

Figure 18. Briefing Tool interface.

The Briefing Tool uses the "*.show" file created during processing. Figure 19 displays the dialog box opened after pressing the button with the "open file" icon. After the file is opened, a delay of several seconds is experienced while the file is loaded. The Briefing Tool will display the date and time of the first frame in the window when it is ready. Figure 20 depicts the replay of the data recorded and processed in this scenario.

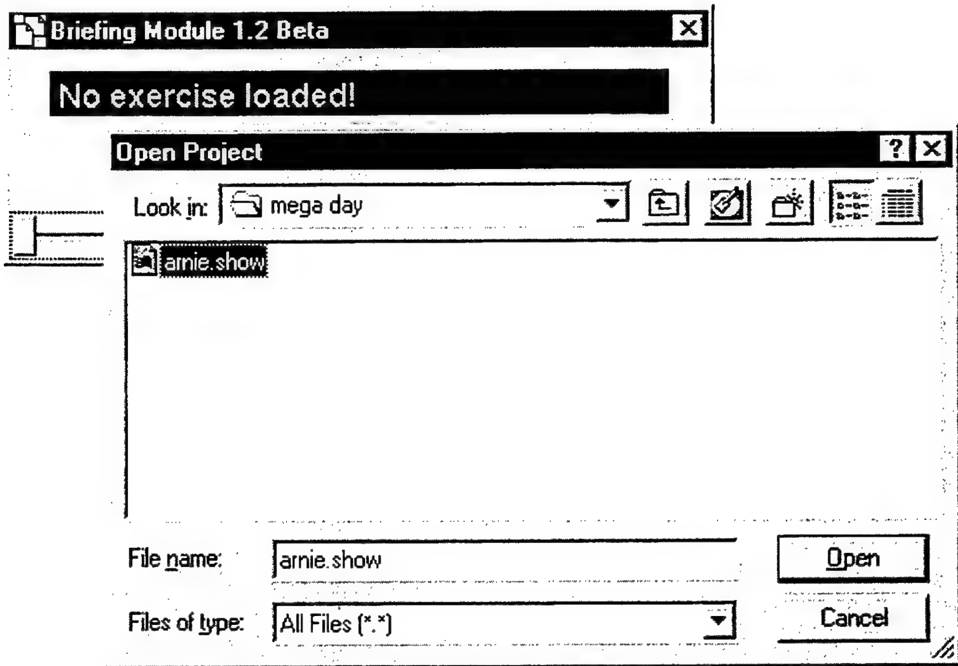

Figure 19. Briefing Tool with dialog box.

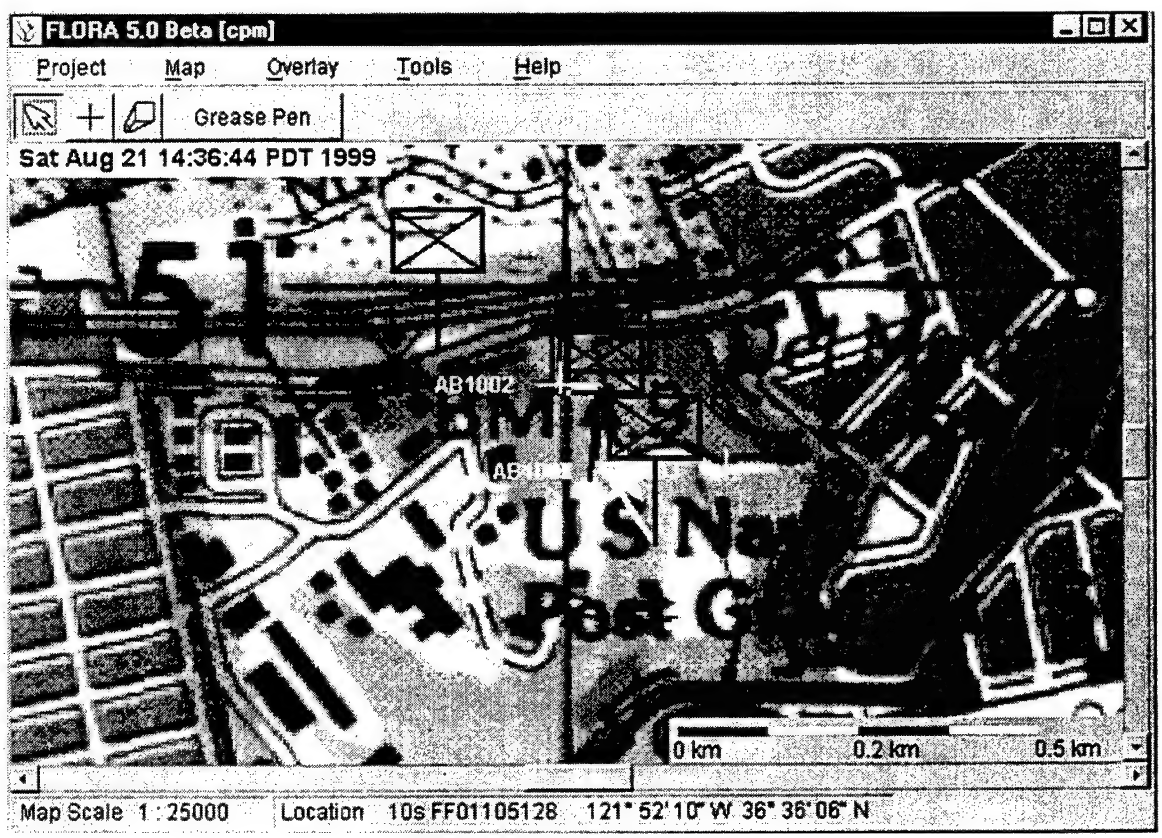

Figure 20. AAR Replay.

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